Troubleshooting Cisco CMTS Based Services

BRKSPG-2501

Agenda

- CMTS Based Services Evolution
- Troubleshooting High Speed Data
  - DOCSIS 3.0 DS and US Channel Bonding Issues
- Troubleshooting Voice Service
  - Troubleshooting Voice Subscriber Issues
- Troubleshooting L2VPN BSoD
- Q & A
- Summary

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CMTS Services Landscape

- Massive HFC Infrastructure
- High Speed Data
  - DOCSIS 1.x and 2.0 services
  - DOCSIS 3.0 high speed services
- QoS Rich Services
  - Voice and PCMM services
  - IPTV
- Is that the end of line for CMTS ?

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The Next Wave – BSoD

- Long history of VPN services over Fiber
- Substantial HFC infrastructure used for residential services only
- Efficient plant utilization for maximum ROI
- Business Services over DOCSIS – **BSoD**
- New diagnostic tools for new services

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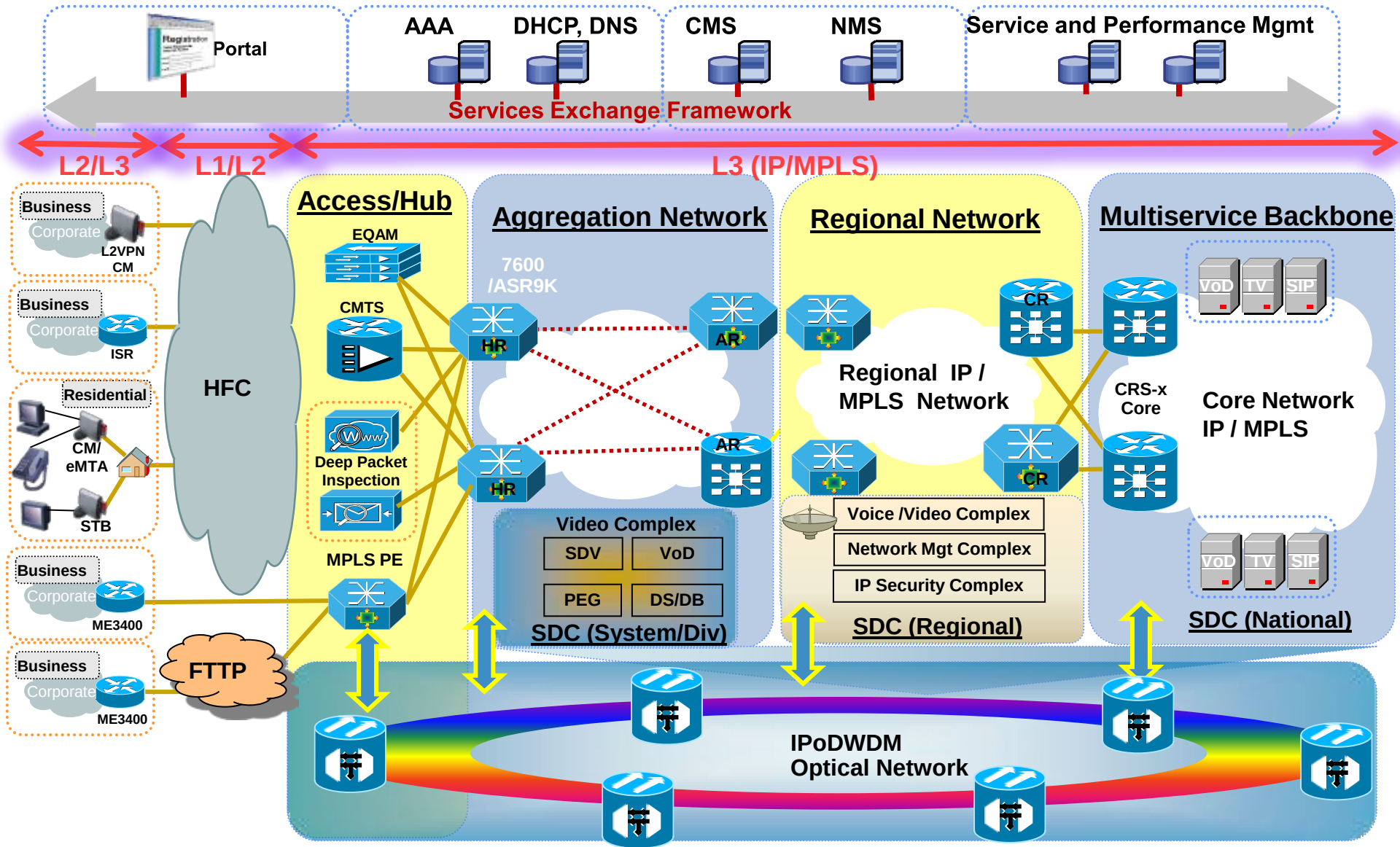
Cable Multi Service Networks



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Troubleshooting High Speed Data Services

Common Issues

- DOCSIS 3.0 DS Channel Bonding Issues
  - CMs not coming up as w-online or Bonding Capable
  - Poor throughput issues
- DOCSIS 3.0 US Channel Bonding Issues
  - Poor US throughput on USCB modem

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DOCSIS 3.0 DS Channel Bonding Issues

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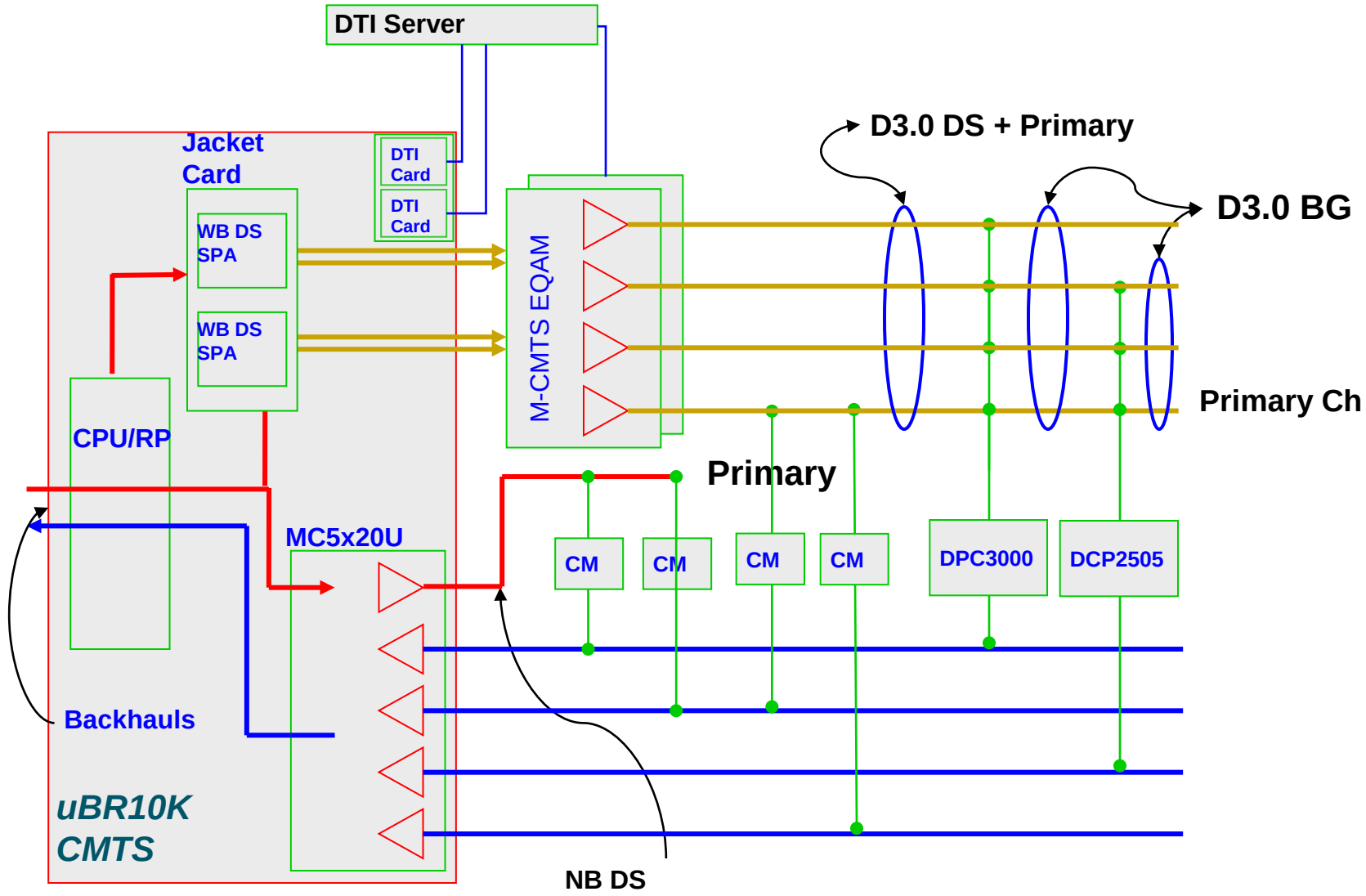
DOCSIS 3.0 M-CMTS System



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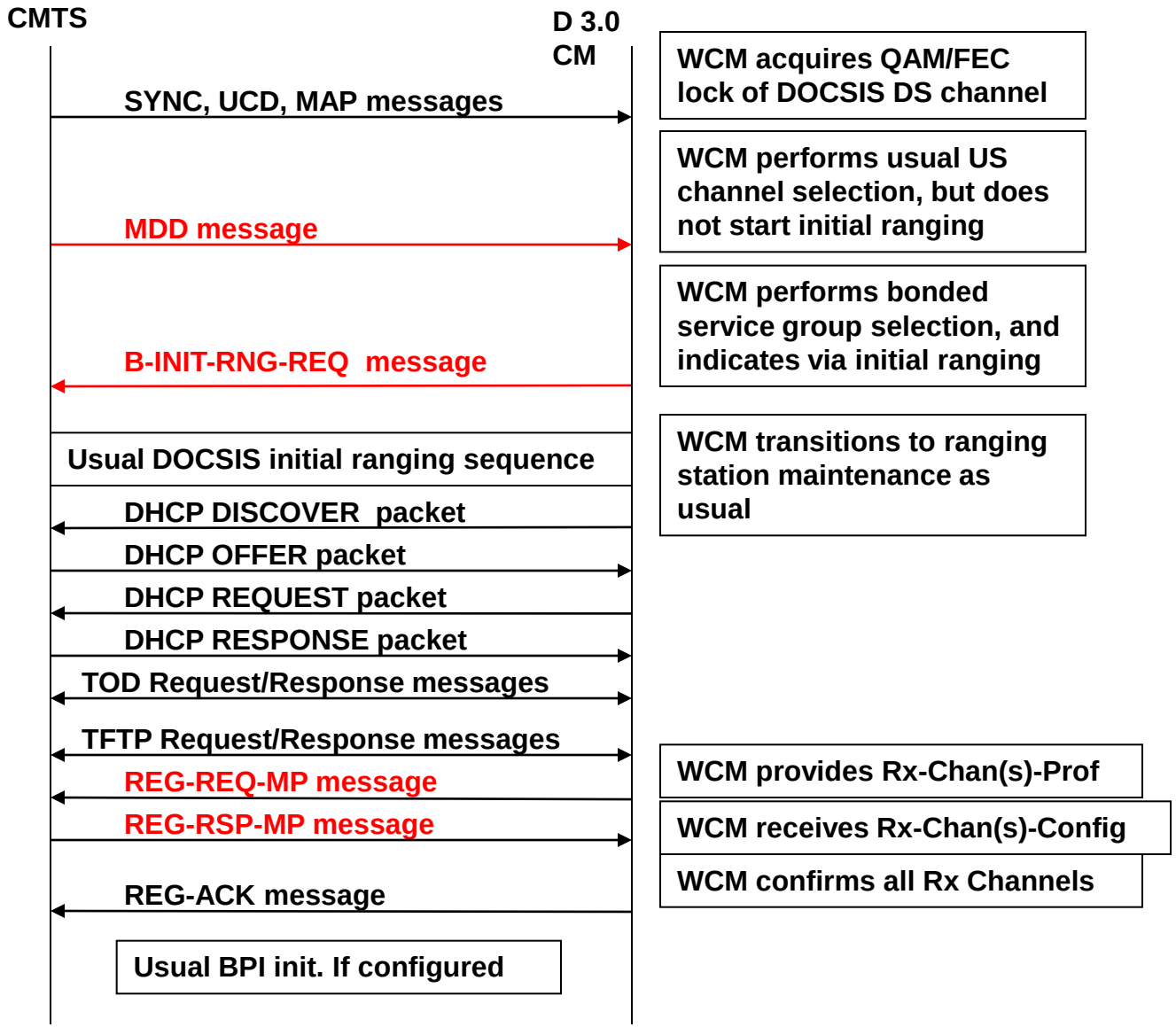
DOCSIS 3.0 Registration Diagram


CMTS
D 3.0 CM
SYNC, UCD, MAP messages
WCM acquires QAM/FEC lock of DOCSIS DS channel
MDD message
WCM performs usual US channel selection, but does not start initial ranging
B-INIT-RNG-REQ message
WCM performs bonded service group selection, and indicates via initial ranging
Usual DOCSIS initial ranging sequence
WCM transitions to ranging station maintenance as usual
DHCP DISCOVER packet
DHCP OFFER packet
DHCP REQUEST packet
DHCP RESPONSE packet
TOD Request/Response messages
TFTP Request/Response messages
REG-REQ-MP message
WCM provides Rx-Chan(s)-Prof
REG-RSP-MP message
WCM receives Rx-Chan(s)-Config
REG-ACK message
WCM confirms all Rx Channels
Usual BPI init. If configured

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CMs not coming up as w-online

Possible reasons

- 1. Improper configuration
  - 1.a - Verify MC interface, WB interface, CGD and Fiber-node configuration
  - 1.b - MDD issues
- 2. Connectivity issues between the M-CMTS components
  - 2.a - Between M-CMTS components and DTI server
  - 2.b - Between the CMTS and EQAM
- 3. RF side combining issues at the headend

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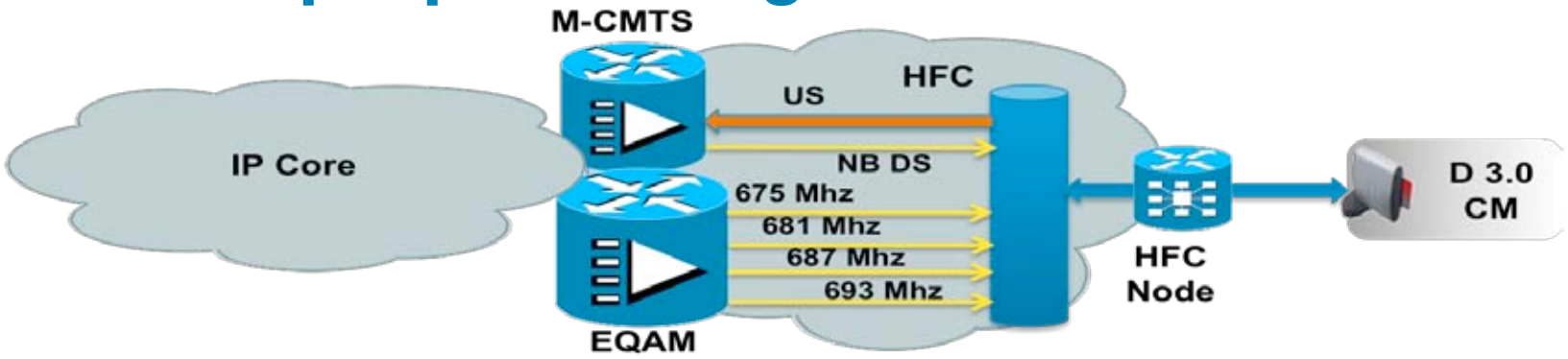
1.a - Improper Configuration Checklist



Controller configuration verification

IP of WB-SPA

Parent Cable LC for resources

DEPI remote ID and Port

IP of EQAM

Mac-Add of EQAM

```
controller Modular-Cable 1/0/0
 ip-address 12.30.4.101
 modular-host subslot 5/0
 rf-channel 0 cable downstream channel-id 24
 rf-channel 0 frequency 675000000 annex B modulation 256qam interleave 32
 rf-channel 0 ip-address 12.30.4.100 mac-address 0090.f001.9312 depi-remote-id 50001
 rf-channel 1 cable downstream channel-id 25
 rf-channel 1 frequency 681000000 annex B modulation 256qam interleave 32
 rf-channel 1 ip-address 12.30.4.100 mac-address 0090.f001.9312 udp-port 50002
 rf-channel 2 cable downstream channel-id 26
 rf-channel 2 frequency 687000000 annex B modulation 256qam interleave 32
 rf-channel 2 ip-address 12.30.4.100 mac-address 0090.f001.9312 udp-port 50003
 rf-channel 3 cable downstream channel-id 27
 rf-channel 3 frequency 693000000 annex B modulation 256qam interleave 32
 rf-channel 3 ip-address 12.30.4.100 mac-address 0090.f001.9312 udp-port 50004
```

Modular-Cable interface configuration verification

Bundle ID inherited from LC, need to match with wideband interface

BW has to be configured

```
interface Modular-Cable1/0/0:0
 cable bundle 123
 cable dynamic-bw-sharing
 cable rf-bandwidth-percent 46
```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1.a - Improper Configuration Checklist

Wideband interface verification

```
interface Wideband-Cable1/0/0:0
 load-interval 30
 cable bundle 123
 cable dynamic-bw-sharing
 cable bonding-group-id 1
 cable rf-channel 0 bandwidth-percent 50
 cable rf-channel 1 bandwidth-percent 50
 cable rf-channel 2 bandwidth-percent 50
 cable rf-channel 3 bandwidth-percent 40
```

Bundle ID that should match under modular interface

DS Bonding Group config

Fiber-node configuration verification

```
sh cable fiber-node
Fiber-Node          Config Status
Fiber-Node 101
       downstream Modular-Cable 1/0/0:  0-3
       upstream Cable 5/0:  0-3
    FN Config Status: Configured (status flags = 0x01)
    MDD Status: Valid
```

Fiber Node with RF channels

MDD has to be valid

CGD association verification

```
show cable cgd-associations
CGD Host   Resource   DS Channels          Upstreams (AllUS)   Active Remote DS
Ca5/0/0    5/0/0      0                    0-3                 Yes
           1/0/0      0                    0-3
                                                               0
Ca5/0/1    5/0/1      0                    0-3                 Yes
           1/0/0      4                    0-3                 Yes
```

NB cable intf. With RF channels

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1.a - Improper Configuration Checklist

Primary channel SYNC and MAP verification

```
UBR10K#show hw-module bay 1/0/0 counters rf-channel
SPA     RF     MPEG                  MPEG       MPEG      Sync          MAP Queue
        Chan   Packets Tx             bps        Mbps      Packets Tx    Packets Tx
1/0/0   0      5406341508            29337376   29.743    1105170888    20849541696
1/0/0   1      5352261326            29280123   29.280    0             0
1/0/0   2      5352239729            29274528   29.274    0             0
1/0/0   3      5352276150            29251244   29.251    0             0
```

Sync and MAP packets on PC channel

RF-Channel mapping verification

```
UBR10K#show hw-module bay 1/0/0 mapping rf-channel
SPA       RF        MC          MC Rem.     WB          WB          WB Rem.
          channel   BW %        Ratio       channel     BW %        Ratio
1/0/0     0         46          1           0           50          1
1/0/0     1         0           -           0           50          1
1/0/0     2         0           -           0           50          1
1/0/0     3         0           -           0           40          1
```

WB interface BW

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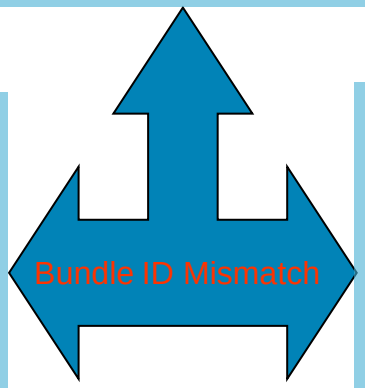
1.b - Invalid MDD State for a Fiber Node

Fiber node Configuration

```
sh cable fiber-node
Fiber-Node          Config Status
Fiber-Node 101
       downstream Modular-Cable 1/0/0:  0-3
       downstream Cable 6/1/0
    FN Config Status: Configured (status
flags = 0x09)
    MDD Status: InValid
        Bundle ID Inconsistent
```

Bonding Group Configuration

```
interface Wideband-Cable1/0/0:0
 load-interval 30
 cable bundle 125
 cable dynamic-bw-sharing
 cable bonding-group-id 1
 cable rf-channel 0 bandwidth-percent 70
 cable rf-channel 1
 cable rf-channel 2
 cable rf-channel 3
```



Host Interface Configuration

```
interface Cable6/1/0
 load-interval 30
 downstream Modular-Cable 1/0/0
rf-channel 0
 no cable mtc-mode
 cable cm-status enable 1-10
 no cable packet-cache
 cable bundle 123
 cable downstream channel-id 119
```

Checkpoints for bad MDD:

DS Frequencies has to be same on CMTS and EQAM

Unique DS channel IDs for DSs under fiber-node configuration

Non-overlapping frequencies for DSs and USs under fiber-node

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1.b - MDD verification

- Debugs to verify MDD generation on CMTS
  - debug cable interface cable x/y/z verbose
  - debug cable mdd
- Debugs needed for ranging and registration
  - debug cable mac-address <CM mac-add> verbose
  - debug cable mdd
  - debug cable ranging
  - debug cable registration
  - debug cable tlv
  - Debug cable dhcp
  - debug cable service-ds-selection

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1.b - Sample MDD Debug from PC Channel

```
Mar 24 09:06:00.648: Cable5/0/0 MDD datagramsize
333, msg len 331, ehdr type_or_len 313, tlv_size
303 max_pak_size 1518
MDD MESSAGE
 FRAME HEADER
  FC, MAC_PARM, LEN       - 0xC2, 0x00, 0x014B
   MAC MANAGEMENT MESSAGE HEADER
    DA, SA          - 01E0.2F00.0001,0014.F1E6.20D0
    msg LEN                 - 0x0139
    DSAP, SSAP              - 0, 0
    control,version,type    - 0x03, 0x04, 0x21
    change_count            - 0x29
    num_fraqment, seq_num   - 0x01, 0x01
    dcid                    - 24
MDD TLV, Total TLV size - 303
      MDD TLV
       Downstream Active Channel List
         Channel ID:             24
         Frequency:              675000000Hz
         Modulation Order/Annex: 256 QAM/Annex B
         Primary Capable:        Primary-Capable
         CM-STATUS Event Bitmask:0x36
                                 MDD Timeout
                                 QAM FEC failure
                                 MDD Recovery
                                 QAM FEC recovery
       Downstream Active Channel List
         Channel ID:             25
         Frequency:              681000000Hz
         Modulation Order/Annex: 256 QAM/Annex B
         Primary Capable:       Not Primary-Capable
         CM-STATUS Event Bitmask:0x36
                                 MDD Timeout
                                 QAM FEC failure
                                 MDD Recovery
                                 QAM FEC recovery
```

```
Downstream Active Channel List
    Channel ID:             26
    Frequency:              687000000Hz
    Modulation Order/Annex: 256 QAM/Annex B
    Primary Capable:        Not Primary-Capable
<snip>
Downstream Active Channel List
    Channel ID:             27
    Frequency:              693000000Hz
    Modulation Order/Annex: 256 QAM/Annex B
    Primary Capable:        Not Primary-Capable
<snip>
    MAC Domain Downstream Service Group
    MD-DS-SG ID:            1
    Channel IDs:            24
                             25
                            26
                            27
Downstream Ambiguity Resolution Frequency List
         Frequencies:            675000000Hz
                                 681000000Hz
                                 687000000Hz
                                 693000000Hz
       IP Initialization Parameters
         IP Provisioning Mode:   IPv4
       Receive Channel Profile Reporting Control
         Center Freq spacing:    6 MHz
         Verbose Reporting:      No
       Early Authentication and Encryption (EAE)
         Early Authentication:   Disabled
       Symbol Clock Locking Indicator
         Locked to Master:       Locked
CM-STATUS Event Control
         Event Type Code:        MDD Timeout
         Event Holdoff Timer:    50 (20 ms) ticks
```


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1.b - Debug CM's Ranging to Registration

Bonding Initial Request on MD-DS-SG 1

Initial Ranging

```
Mar 24 09:06:22.624: Bonding Initial Ranging request from 0023.be50.e628, SID 0
[16383] on Interface Cable5/0/0/U2: MD-DS-SG-ID 1, Cap flags 192Src sap 137
Mar 24 09:06:22.624: Initial Ranging: Downstream channel ID is 24 (CGD host DS chan
Id 119)
Mar 24 09:06:22.624: CM mac address found. Assigned Primary SID 23.
Mar 24 09:06:22.624: Modem 0023.be50.e628: Host Ca5/0/0/U2: ds_channel_id 24, rfid 0
```

Ambiguity and Ranging response

```
Mar 24 09:06:23.464: 0023.be50.e628: usambi from channel 3 to channel 3
Mar 24 09:06:23.464: CM Ambiguity Resolution Done SG_ID=161
Mar 24 09:06:23.464: Initial Ranging: Downstream channel ID is 24 (CGD host DS chan Id
119) ds-sg 1 us-sg 161
Mar 24 09:06:23.464: Reusing old primary sid 23 for modem 0023.be50.e628
Mar 24 09:06:23.464: Modem 0023.be50.e628: Host Ca5/0/0/U2: ds_channel_id 24, rfid 0
Mar 24 09:06:23.464: Ca5/0/0/U2: Send RNG-RSP (1) for 0023.be50.e628, SID 23, DS RFID
0
```

Ranging Response from CMTS

DHCP Boot Request from CM

IP address assignment begins

```
*Mar 24 09:06:24.504: DHCPGLEAN input idb Bundle123 MAC 0023.be50.e628 SID 23 type 1
*Mar 24 09:06:24.504: op = 1 - BOOTREQUEST  htype = 1  hlen = 6  hops = 0
*Mar 24 09:06:24.508: xid = 0x7ECFA2C3   secs = 0   flags = 0x0
*Mar 24 09:06:24.508: ciaddr = 0.0.0.0              yiaddr = 0.0.0.0
*Mar 24 09:06:24.508: siaddr = 0.0.0.0              giaddr = 0.0.0.0
*Mar 24 09:06:24.508: chaddr = 0023.be50.e628       sname =
*Mar 24 09:06:24.508: filename =
*Mar 24 09:06:24.508: DHCP Option 53  - Message Type: 1 - DHCPDISCOVER
```


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1.b - Debug CM's Ranging to Registration

Registration Request

REG-REG-MP request from DSCB CM

```
Mar 24 09:06:28.188: Receive REG-REQ-MP from 0023.be50.e628, SID 23 on Cable5/0/0
Mar 24 09:06:28.188: CM 0023.be50.e628 on Cable5/0/0: Append 239 bytes of REG-REQ-MP
TLV at offset 0
Mar 24 09:06:28.188:  Now parse REG-REQ-MP 1/1 for CM 0023.be50.e628
```

RCPs and Registration response

```
Mar 24 09:06:28.188: Found Network Access TLV
Mar 24 09:06:28.188: Ntw Access Control : 1
Mar 24 09:06:28.188: Found Max CPEs TLV
<snip.
Mar 24 09:06:28.188: Found Modem Capabilities TLV
Mar 24 09:06:28.188:          Concatenation Support : 1
<snip>
Mar 24 09:06:28.188: Found RCP TLV
Mar 24 09:06:28.188: RCP ID:
Mar 24 09:06:28.188: 0x0000: 00 10 00 00 02
Mar 24 09:06:28.188: Found RCP TLV
Mar 24 09:06:28.188: RCP ID:
Mar 24 09:06:28.188: 0x0000: 00 10 00 00 03
<snip>
Mar 24 09:06:28.190: Selected RCC 41 with total current cms 1 for Cable5/0/0 8
channel modem 0023.be50.e628, (4 rcc rfs) BG 1
Mar 24 09:06:28.190: Performing admission control check for MTC CM 0023.be50.e628
Mar 24 09:06:28.190:  Assign the candidate TCS to 0023.be50.e628: 0xF
Mar 24 09:06:28.190:  Now sending 2 REG-RSP-MP fragment(s) for CM 0023.be50.e628
Mar 24 09:06:28.190: REG-RSP-MP Status : ok (0), REG-ACK required from CM (0)
```

RCP from CM

RCC 41 selected for CM

REG-RSP-MP for REG-REQ-MP

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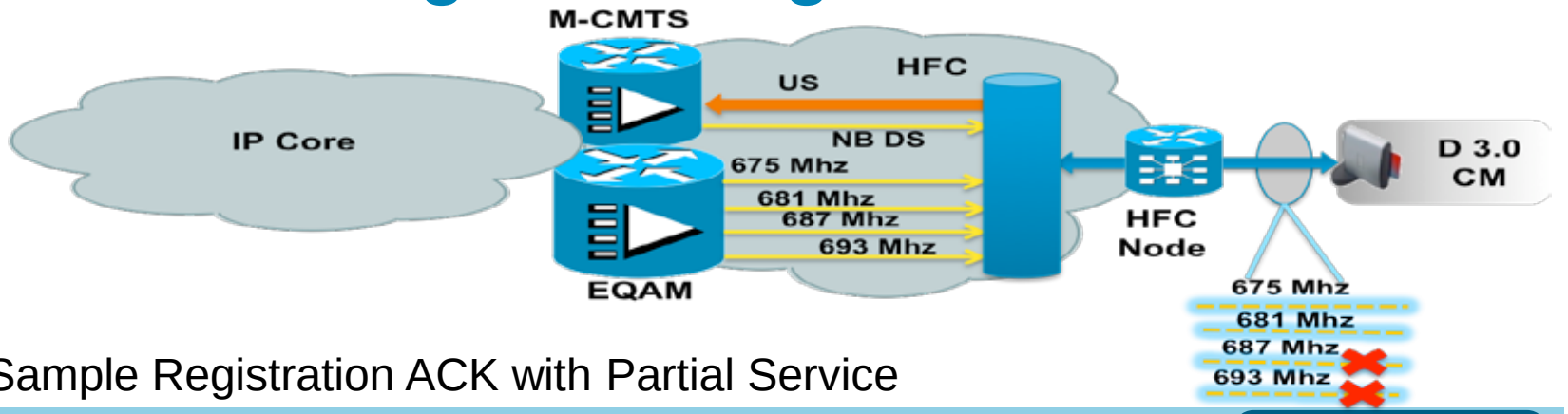
1.b - Debug CM's Registration status



Sample Registration ACK with Partial Service

```
Mar 24 09:06:30.225: Cable5/0/0: CM 0023.be50.e628 REG-ACK response
Mar 24 09:06:30.225: partial-service:
Mar 24 09:06:30.225:     0x0000: 31 04 06 02 03 02
Mar 24 09:06:30.225: Cable5/0/0: CM 0023.be50.e628 ds-chid 3 is impaired
Mar 24 09:06:30.225: Cable5/0/0: CM 0023.be50.e628 ds-chid 2 is impaired
```

Partial Service indicating impaired channels

Modem Status the way modem reports

```
UBR10K2#show cab mode 0023.be50.e628 wideband rcs-status
RF   : 1/0/0 1
  Status                    : UP
  FEC/QAM Failure           : 0
  MDD Failure               : 0
  <snip>
  Flaps                     : 0
  Flap Duration             : 00:00
RF   : 1/0/0 2
  Status                    : UP
  <snip>
RF   : 1/0/0 3
  Status                    : UP
  FEC/QAM Failure           : 0
```

Status reported by CM for individual DS channel

No MDD failure on this channel

No Flaps on this channel

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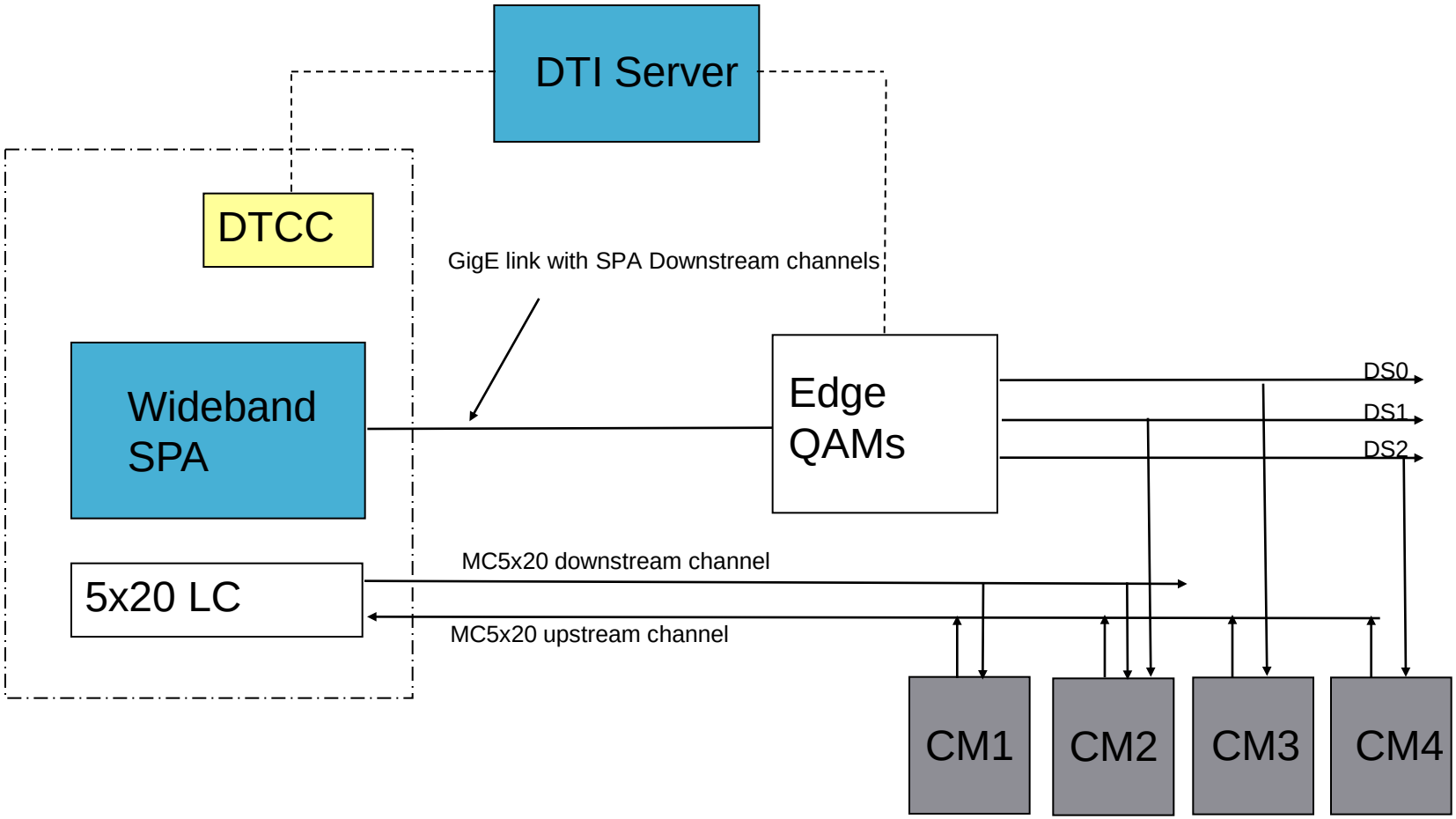
2 – Connectivity between M-CMTS Components

DTI in M-CMTS system



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2.a - Connectivity between M-CMTS and DTI

- Verify that the CMTS and EQAM are locked to the same DTI clock source
- Issue “show cable clock dti pt_server” and look for

  Root Server IPv4 address : <ip of DTI server>
- Issue “show cable clock”

```
UBR10K2#show cable clock
Number of TCC Cards in the Chassis: 2
Active TCC Card is in slot: 1 subslot: 0,(DTCC Eightbells card)
Clock reference used by the active card is DTI
Active TCC card in slot 1/0
TCC Card 1/0 DTI status:
----------------------------------------
    Active Client port              : 2
    Active Client status            : normal
    Active Client Server status     : freerun
    Active Client frame error rate  : < 2%
    Active Client CRC error count   : 0x02
    Standby Client Signal detected  : no
```

DTI used for Clocking

Status has to be normal

<2% error rate is normal

- “ACTIVE” LED status on DTI port

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2.b - Connectivity between CMTS and EQAM

- The effect

Link flap may cause CMs to re-initialize

Interface up/down message for MC and WB interface in the logs

CM may be online on PC channel from 5x20

With “cable wideband auto-reset”, 3.0 CMs will bounced on re-establishment

CMTS relies on timers for detection of indirect link failure

```
UBR10K2#show controllers modular-Cable 1/0/0 brief
SPA 0 is present
status LED: [green]
<snip>
Gigabit Ethernet Port Selected : Port 0
Receive Interface              : Out of Reset
Receive Interface              : Enabled
Transmit Interface             : Out of Reset
<snip>
SFP [Port 0] : 1000BASE-SX Present
 Tx Enabled , LOS Not Detected , TxFault Not Detected
 Link Status [Port 0] : UP
<snip>
RF Channel information
Modulation Data :GE Interframe Gap = 12 , MPEG-TS Frames per pkt = 7
SPA IP address = 12.30.4.101       SPA MAC Addr = 0014.F1E6.2070
QAM         MOD    ANNEX     TKB Interval     Rate adjust   State
0         QAM 256  Annex B     2423             132          Enabled
```


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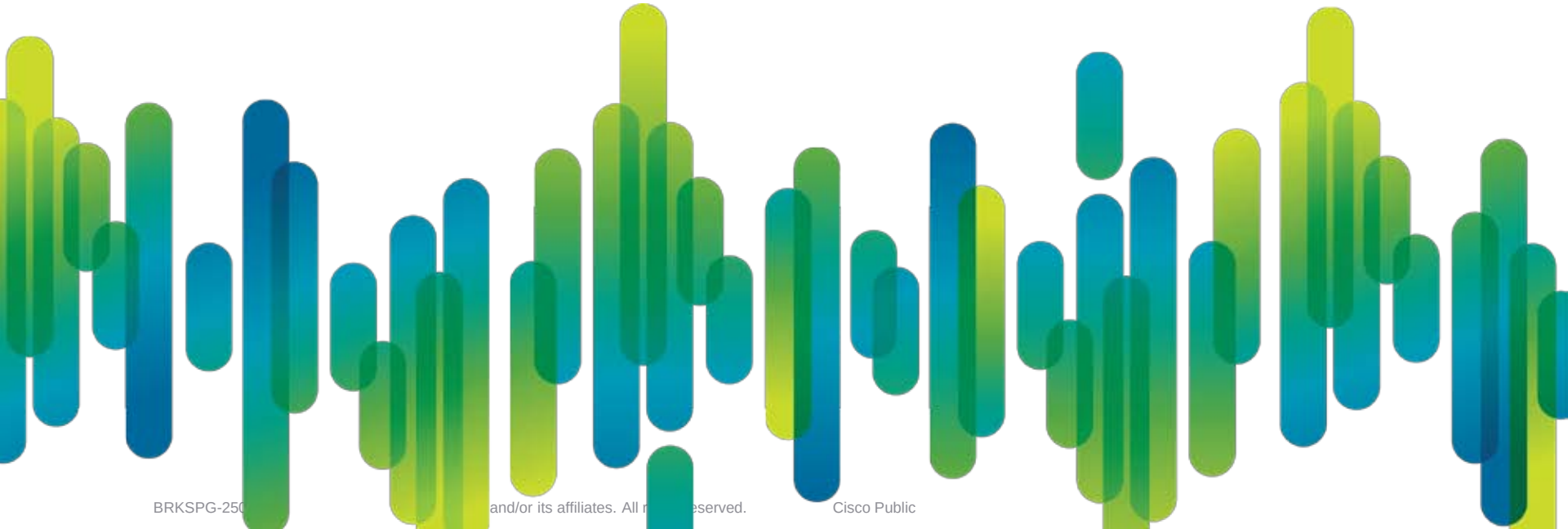
Poor Throughput Issues



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CMs reporting poor throughput

Best way to troubleshoot is

- 1. Look at overall interface numbers on CMTS
  - rf-channel bandwidth sharing, DBS Vs Static
- 2. Per CM throughput verification
  - Identify the subscriber's CM having a problem
    - Perform throughput test
    - Look at the real numbers on CMTS
  - Install a test CM at headend on same US/DS interface, if possible
    - Perform FTP test from server behind CMTS
    - Look at the real numbers on CMTS

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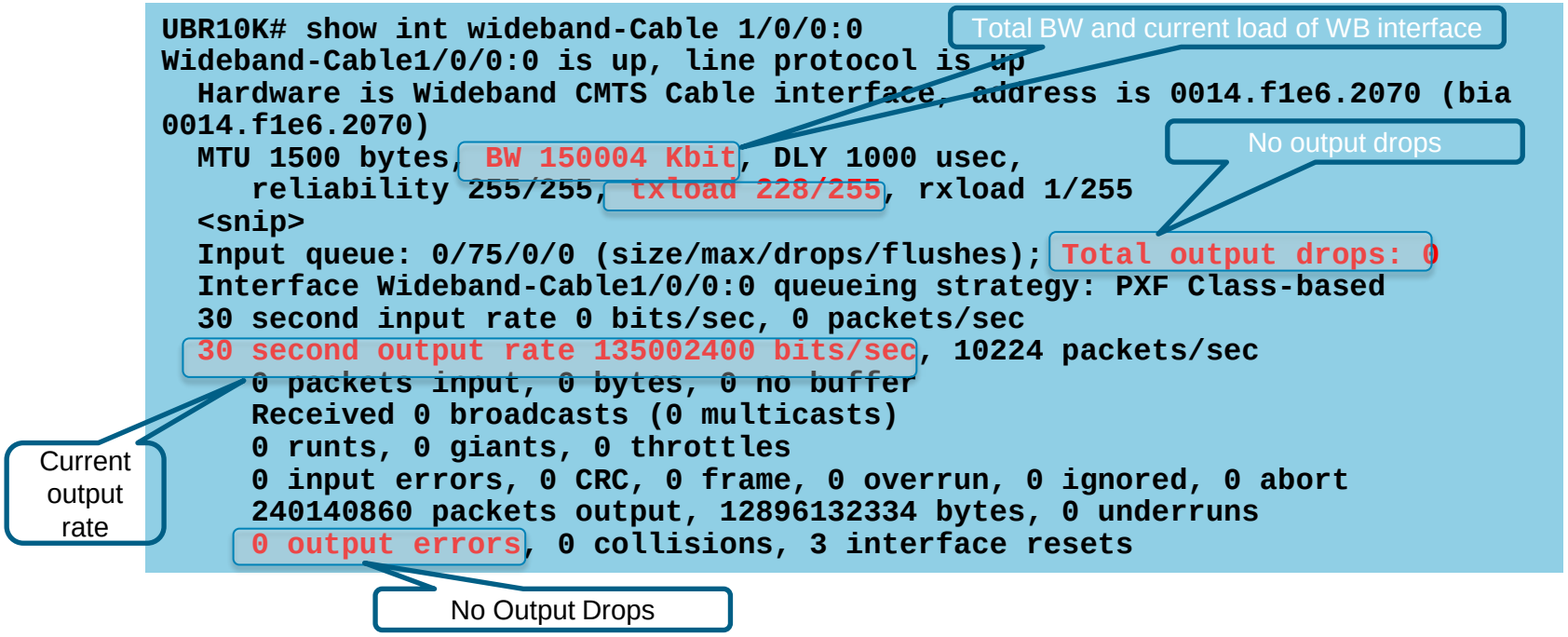
1. CMTS interface numbers

- Configuration check for rf-channel bandwidth sharing

  Dynamic Bandwidth Sharing, DBS, recommended

- show interfaces wideband-Cable x/y/z:j


UBR10K# show int wideband-Cable 1/0/0:0
Wideband-Cable1/0/0:0 is up, line protocol is up
Hardware is Wideband CMTS Cable interface, address is 0014.f1e6.2070 (bia
0014.f1e6.2070)
MTU 1500 bytes, BW 150004 Kbit, DLY 1000 usec,
reliability 255/255, txload 228/255, rxload 1/255
<snip>
Input queue: 0/75/0/0 (size/max/drops/flushes); Total output drops: 0
Interface Wideband-Cable1/0/0:0 queueing strategy: PXF Class-based
30 second input rate 0 bits/sec, 0 packets/sec
30 second output rate 135002400 bits/sec, 10224 packets/sec
0 packets input, 0 bytes, 0 no buffer
Received 0 broadcasts (0 multicasts)
0 runts, 0 giants, 0 throttles
0 input errors, 0 CRC, 0 frame, 0 overrun, 0 ignored, 0 abort
240140860 packets output, 12896132334 bytes, 0 underruns
0 output errors, 0 collisions, 3 interface resets
Total BW and current load of WB interface
No output drops
Current output rate
No Output Drops

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1. Show hw-module counters on CMTS

- Show hw-module bay x/y/z counters rf-channel

```
UBR10K#show hw-module bay 1/0/0 counters rf-channel
SPA    RF    MPEG                  MPEG       MPEG    Sync          MAP Queue
       Chan  Packets Tx            bps        Mbps    Packets Tx    Packets Tx
1/0/0  0     5406341508            29337376   29.743  1105170888
20849541696
1/0/0  1     5352261326            29280123   29.280  0             0
1/0/0  2     5352239729            29274528   29.274  0             0
1/0/0  3     5352276150            29251244   29.251  0             0
```

Current load on each channel

- Show hw-module bay x/y/z counters wideband-channel j

  Look for Tx packets increment

- Monitor channel utilization in EQAM

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2. Per CM DS and US throughput verification

Show commands to be used

- Show cable modem <mac/ip-add> wide rcs-status

  Make sure CM is not in “Partial Service”

  Status will be p-online for DS partial service in future IOS

- Show cable modem <mac/ip-add> service-flow

```
UBR10K2#show cable modem 10.10.2.6 service-flow
SUMMARY:
MAC Address    IP Address     Host         MAC              Prim Num Primary    DS
                              Interface    State            Sid  CPE Downstream RfId
0023.be50.e628 10.10.2.6      C5/0/0/U0    w-online(pt)     28    0   Mo1/0/0:0  0
Forwarding Interface: Wideband-Cable 1/0/0:0
Sfid  Dir Curr  Sid   Sched  Prio MaxSusRate  MaxBrst   MinRsvRate  Throughput
          State       Type
100   US  act   28    BE     0    5000000      8192      0           846
101   DS  act   N/A   BE     0    101000000    3044      0           99000124
```

Primary Sid of CM

Current throughput

- US MAP grants and pxf QID

```
UPSTREAM SERVICE FLOW DETAIL:
SFID  SID   Requests   Polls      Grants     Delayed    Dropped    Packets
                                             Grants     Grants
100   28    0          0          1323750    0          0          123933740
DOWNSTREAM SERVICE FLOW DETAIL:
SFID  RP_SFID  QID     Flg Policer                Scheduler
                       Xmits      Drops      Xmits      Drops
101   33153    854     14318351   0          14131275   0
```

No Dropped or Delayed grants

PXF Qid for DS service flow

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2. Show pxf cpu queue qid

12.3(23)BC7

```
UBR10K#show pxf cpu queue 854
ID                                  : 854
CIR (in-use/configured)             : 0/0
EIR (in-use/configured)             : 256/256
MIR (in-use/configured)             : 58835/58835
Link                                : 32512
MIR Truncated BW                    : 5823
Flowbit (period/offset)             : 512/128
Burst Size                          : 1024 bytes
Actual Bundle FIFO Size             : 0
Bandwidth                           : 112505 Kbps
Channel                             : 0
Packet Descriptor Base              : 0x000D4800
Length/Average/Max/Alloc            : 216/0/256/256
Enqueues (packets/octets)      : 16460426/3676560776
Dequeues (packets/octets)      : 16460207/3676220760
Drops (tail/random/max_threshold): 2104690/0/0
Drops (no_pkt_handle/buffer_low) : 0/0
WRED (weight/avg_smaller)           : 0/0
WRED (next qid/drop factor)         : 0/0
WRED (min_threshold/max_threshold/scale/slope):
precedence 0                        : 0/0/0/0
precedence 1                        : 0/0/0/0
precedence 2                        : 0/0/0/0
precedence 3                        : 0/0/0/0
precedence 4                        : 0/0/0/0
precedence 5                        : 0/0/0/0
precedence 6                        : 0/0/0/0
precedence 7                        : 0/0/0/0
```

PXF Qid

High tail drops, no packet buffer drops

12.3(23)SCB onwards

```
UBR10K#show cable mode 0023.be50.e628 service-flow
verbose
<snip>

Bytes                                       : 105866
Rate Limit Delayed Packets                  : 0
Rate Limit Dropped Packets                  : 0
Current Throughput      : 0 bits/sec, 0 packets/sec
Application Priority                                : 0

LC_sfid: 101    rp_sfid: 33153  SF-ByteCount:
104678  SF-PacketCount: 539
  SF-ConformXmitBytes: 104678
  SF-ConformXmitPkts: 539
  SF-ExceedXmitBytes:  0
  SF-ExceedXmitPkts:  0
  SF-ConformDropBytes: 0
  SF-ConformDropPkts: 0
  SF-ExceedDropBytes:  0
  SF-ExceedDropPkts:  0

Queuing/Jib Tables:
  ibus_channel: 49152 ds_key_index: 0    phs_rule:
0 tx_control: 0xD  jib_flag: 0  keyseq_mapcntrl:
0x0  ds_stat_index: 3  min_res_pkt_size: 0
jib_hdr_id: 0x0  docsis_hdr_len: 0
docsis_overhead_len: 12  ds_port: 0
  qid:  131561   tx_pkts: 539  qtail_drop_pkts: 0
```

LC and RP sfid

Qtail_dropped packets

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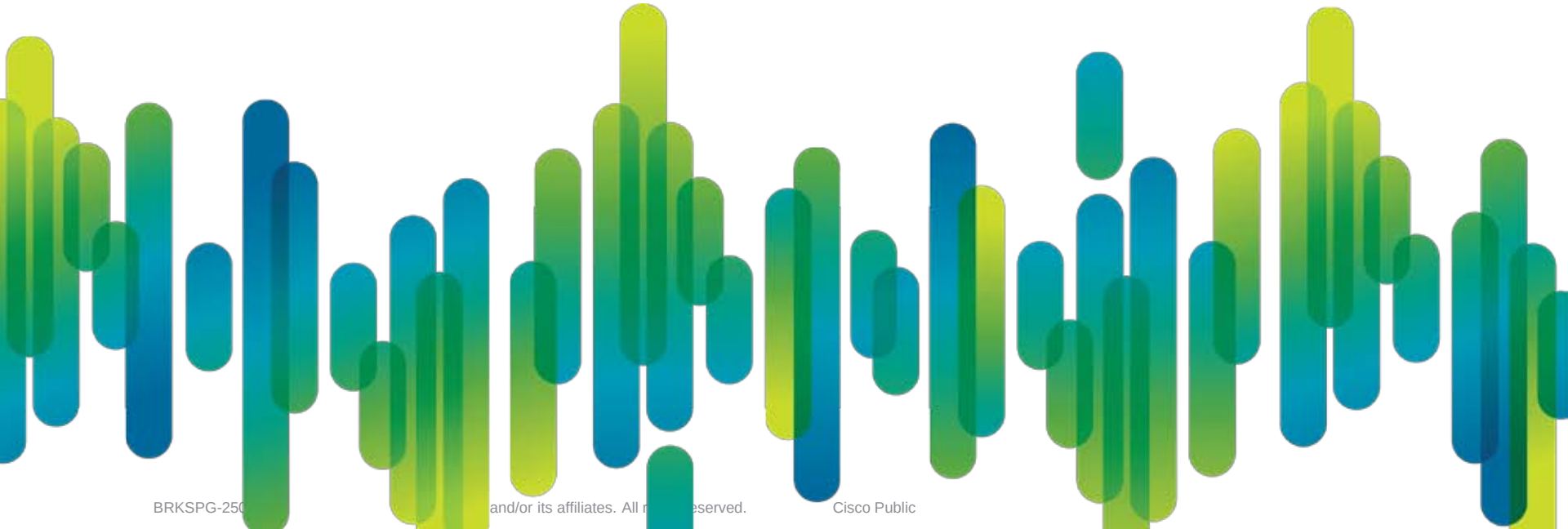
DOCSIS 3.0 US Channel Bonding Issues



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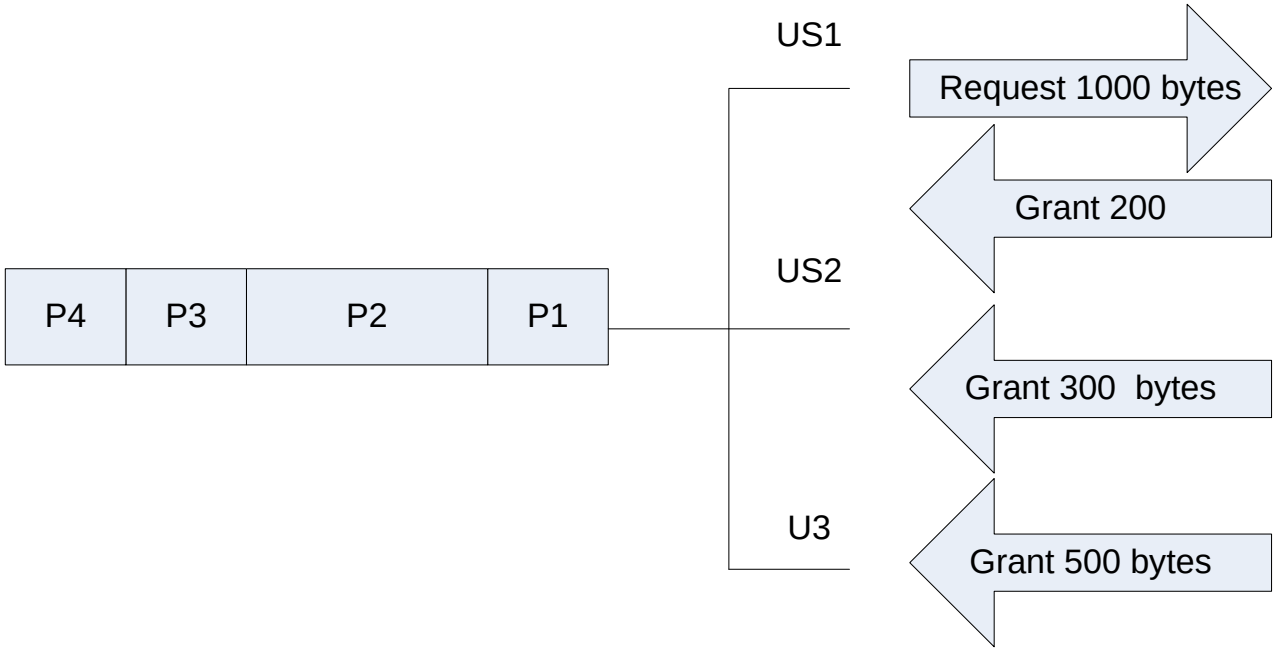
D3.0 Upstream Channel Bonding

- Upstream bonding

  Single flow can consume all BW on multiple USs

- Continuous Concatenation & Fragmentation (CCF)

  Improved form of concatenation and fragmentation



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Troubleshooting USCB modem issues

Common problem

1 - Poor US throughput on USCB modem

- 1.a - Configuration issues
- 1.b - Debugs needed
- 1.c - Show commands and sid tracker verification

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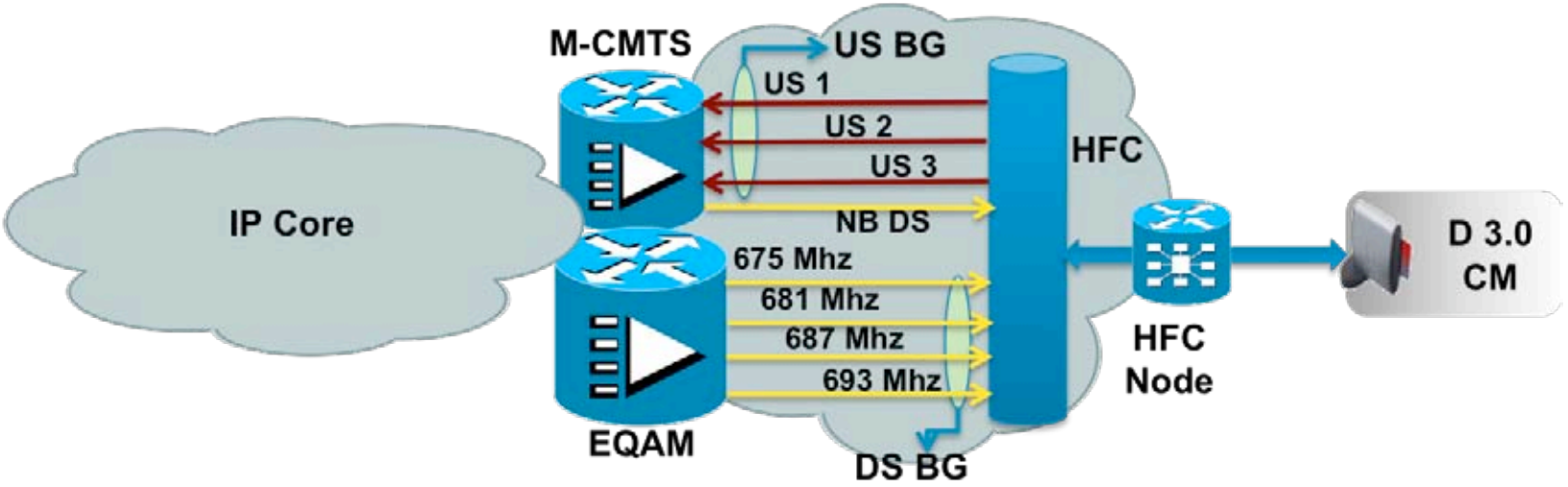
1 – CMTS configuration issues



- CMTS configuration checklist
  - Is DSCB configured?
    - USCB requires DSCB

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1.a - Configuration verification

Cable interface configuration

```
UBR10K2#sh run int cable 5/0/0
interface Cable5/0/0
 load-interval 30
 downstream Modular-Cable 1/0/0 rf-channel 0 upstream 0-3
 cable mtc-mode required-attribute
 no cable packet-cache
 cable cm-status enable 1-10
 cable bundle 123
 cable downstream channel-id 119
 cable downstream annex B
 cable downstream modulation 256qam
 cable downstream interleave-depth 32
 cable downstream frequency 615000000
 cable downstream rf-shutdown
 cable upstream max-ports 4
 cable upstream bonding-group 257
  upstream 1
  upstream 2
  upstream 3
  attributes A0000000
```

Default CLI. Need to have attribute in CM config file

Cable bundle interface association

US BG definition with US channels
Attribute needs to match in CM config file

Attributes value: A=1010
bit0 = Bonding, bit1= Low Latency, bit2=High Availability, bit3-15=Reserved for future use

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1.a - Configuration verification contd..

Fiber-node configuration verification

```
cable fiber-node 104
  downstream Modular-Cable 1/0/0 rf-channel 0-3
  upstream Cable 5/0 connector 1-3
```

US connector addition under fiber-node

MDD status verification

```
Fiber-Node 104
       downstream Modular-Cable 1/0/0:  0-3
       upstream Cable 5/0:  1-3
    FN Config Status: Configured (status flags = 0x01)
    MDD Status: Valid
```

MDD status has to be Valid

Mac-domain service group verification

```
UBR10K2# show cable mac-domain cable 5/0/0 upstream-service-group
Cable MD 5/0/0
  US-SG-ID  : 169        US-Chan : U1,2,3
  US-SG-ID  : 170        US-Chan : U0,1
  US-SG-ID  : 172        US-Chan : U0,1,2,3
  US-SG-ID  : 173        US-Chan : U1,2
  Primary-DS: 1/0/0:0    US-SG-ID: 169,170,172,173
    MDD US-List    : U0,1,2,3
    MDD Ambiguity : U0,2,3
```

US service Group with US channel association

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1.b - Debugs USCB ranging and registration

- debug cable mac-address 0023.be50.e628 verbose
- Debug cable mdd
- Debug cable registration
- Debug cable range initial
- debug cable md-sg
- debug cable range
- debug cable range protocol
- Debug cable ubg

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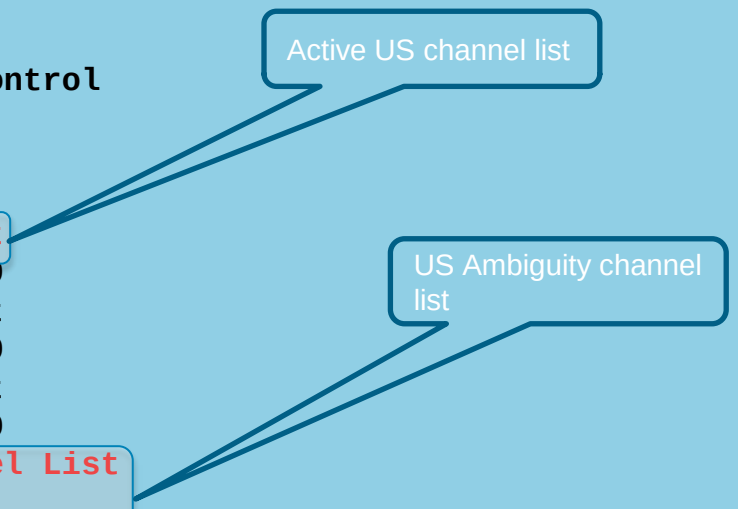
1.b - Updated MDD with US channels

Debug cable mdd will have active US channels

```
<snip>
Downstream Ambiguity Resolution Frequency List
         Frequencies:              675000000Hz
                                   681000000Hz
                                   687000000Hz
                                   693000000Hz
       IP Initialization Parameters
         IP Provisioning Mode:     IPv4
       Receive Channel Profile Reporting Control
         Center Freq spacing:      6 MHz
         Verbose Reporting:        No
<snip>
       MAC Domain Upstream active chan list
         MD-US Chan ID/CM-STATUS:  1/0x0000
       MAC Domain Upstream active chan list
         MD-US Chan ID/CM-STATUS:  2/0x0000
       MAC Domain Upstream active chan list
         MD-US Chan ID/CM-STATUS:  3/0x0000
       Upstream Ambiguity Resolution Channel List
         MD-US Chan ID:            1 2 3
       Upstream Frequency Range  0
       Upstream Transmit Power Reporting: On
       CM-STATUS non-channel-specific events
:                                 Seq out of range
```



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1.b - Debug CM's Initial RNG-REQ

```
Mar 23 15:17:03.828: Bonding Initial Ranging request from
  0023.be50.e628, SID 0 [16383] on Interface Cable5/0/0/U3: MD-DS-SG-
  ID 1, Cap flags 192Src sap 137
Mar 23 15:17:03.828: Initial Ranging: Downstream channel ID is 24 (CGD
  host DS chan Id 119)
Mar 23 15:17:03.828: cmts_tcc_uschan_add: CM 0023.be50.e628 tcs 0 chan
  3 tech 2 ref 0
Mar 23 15:17:03.828: Modem 0023.be50.e628: Host Ca5/0/0/U3:
  ds_channel_id 24, rfid 0
Mar 23 15:17:03.828: Ambiguity Resolution Validate Candidate:
  (B_INIT_RNG_REQ) found[ 1 ] uschan = 0xF, reachable = 0x8, failed =
  0x0.
<snip>
 Mar 23 15:17:04.252: Timing error 1578, power error -6.50dB, freq
  error 114(thres 640 adj 0) [sm per 15.0 sec]
Mar 23 15:17:04.832: US Adjust TLV12: Added Upstream Channel
  Adjustments TLV, tlvp->length = 6.
Mar 23 15:17:04.848: Initial Ranging: Downstream channel ID is 24 (CGD
  host DS chan Id 119) ds-sg 1 us-sg 169
Mar 23 15:17:04.850: Ca5/0/0/U3: Send RNG-RSP (1) for 0023.be50.e628,
  SID 39, DS RFID 0
<snip>
*Mar 23 15:17:05.188: DHCPINFO hwidb Bundle123 MAC 0023.be50.e628 SID
  39 dhcp_op 1
```


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1.b - Debug CM's REG-REQ and REG-RSP

```
Mar 23 15:17:08.936: Receive REG-REQ-MP from 0023.be50.e628, SID 39 on
  Cable5/0/0

<snip>

Mar 23 15:17:08.940:  Now sending 2 REG-RSP-MP fragment(s) for CM
  0023.be50.e628

Mar 23 15:17:08.940: REG-RSP-MP Status : ok (0), REG-ACK required from
  CM (0)

<snip>

Mar 23 15:17:12.108: RNG-REQ from 0023.be50.e628: state 1

Mar 23 15:17:12.108: Multi-Channel Initial Ranging

Mar 23 15:17:12.108: Ca5/0/0/U3: Send RNG-RSP (1) for 0023.be50.e628,
  SID 39, DS RFID 0

Mar 23 15:17:12.168: Ranging request from 0023.be50.e628, SID 39
  [16383/24/0] on Interface Cable5/0/0/U1

<snip>

Mar 23 15:17:12.228: Ranging request from 0023.be50.e628, SID 39
  [16383/24/0] on Interface Cable5/0/0/U2
```


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1.c - Expanded show commands

Show cable modem with UB for MTC modems

```
UBR10K2#show cable modem 0023.be50.e628

MAC Address    IP Address     I/F          MAC                 Prim RxPwr  Timing Num  D I
                                           State               Sid  (dBmv) Offset CPE  P
0023.be50.e628 10.10.2.6      C5/0/0/UB    w-online            39   -0.50  3018   0    N
```

Up-for partial service mode in future IOS

UB Added for USCB modem

Deep look in to US stats

```
UBR10K2#show cable modem 0023.be50.e628 ver
MAC Address                     : 0023.be50.e628
MD-DS-SG / MD-US-SG             : 1 / 169
<snip>
Multi-Transmit Channel Mode     : Y
Upstream Channel                : US1       US2       US3
Ranging Status                  : sta       sta       sta
Upstream Power (dBmV)           : 0.00      0.00      0.00
Upstream SNR (dB)               : 36.12     36.12     36.12
Received Power (dBmV)           : -0.50     -0.50     0.00
Reported Transmit Power (dBmV)  : 27.25     27.25     27.75
Peak Transmit Power (dBmV)      : 56.00     56.00     56.00
Minimum Transmit Power (dBmV)   : 18.00     18.00     18.00
Timing Offset            (97.6 ns): 3018    3018      3018
Initial Timing Offset           : 1381      1381      1381
Good Codewords rx               : 36472     36473     36475
Corrected Codewords rx          : 0         0         0
Uncorrectable Codewords rx      : 0         0         0
```

DS and US Service Groups for CM

Ranging Status in Station Maintainence. Not in Partial Service.

Other possible Ranging Status: im,sm,Cont,dr,dt and di

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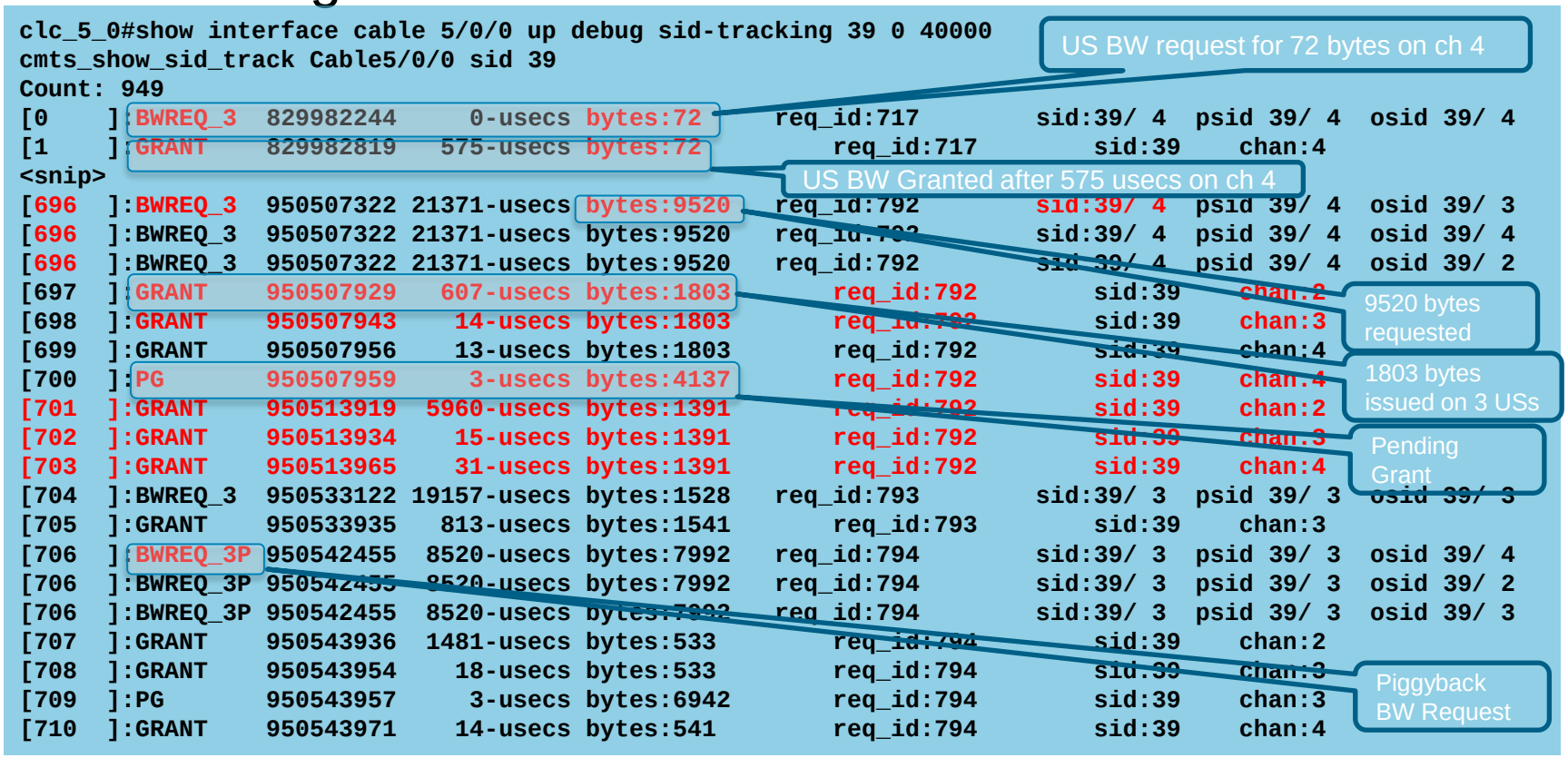
1.c – SID Tracker

- On PRE or LC, Issue “debug cable interface Cable x/y/z sid <sid> track”
- On LC, Issue “show int Cable x/y/z up debug sid-tracking <sid> 0 40000”


clc_5_0#show interface cable 5/0/0 up debug sid-tracking 39 0 40000
cmts_show_sid_track Cable5/0/0 sid 39
Count: 949
[0]:BWREQ_3 829982244 0-usecs bytes:72 req_id:717 sid:39/ 4 psid 39/ 4 osid 39/ 4
[1]:GRANT 829982819 575-usecs bytes:72 req_id:717 sid:39 chan:4
<snip>
[696]:BWREQ_3 950507322 21371-usecs bytes:9520 req_id:792 sid:39/ 4 psid 39/ 4 osid 39/ 3
[696]:BWREQ_3 950507322 21371-usecs bytes:9520 req_id:792 sid:39/ 4 psid 39/ 4 osid 39/ 4
[696]:BWREQ_3 950507322 21371-usecs bytes:9520 req_id:792 sid:39/ 4 psid 39/ 4 osid 39/ 2
[697]:GRANT 950507929 607-usecs bytes:1803 req_id:792 sid:39 chan:2
[698]:GRANT 950507943 14-usecs bytes:1803 req_id:792 sid:39 chan:3
[699]:GRANT 950507956 13-usecs bytes:1803 req_id:792 sid:39 chan:4
[700]:PG 950507959 3-usecs bytes:4137 req_id:792 sid:39 chan:4
[701]:GRANT 950513919 5960-usecs bytes:1391 req_id:792 sid:39 chan:2
[702]:GRANT 950513934 15-usecs bytes:1391 req_id:792 sid:39 chan:3
[703]:GRANT 950513965 31-usecs bytes:1391 req_id:792 sid:39 chan:4
[704]:BWREQ_3 950533122 19157-usecs bytes:1528 req_id:793 sid:39/ 3 psid 39/ 3 osid 39/ 3
[705]:GRANT 950533935 813-usecs bytes:1541 req_id:793 sid:39 chan:3
[706]:BWREQ_3P 950542455 8520-usecs bytes:7992 req_id:794 sid:39/ 3 psid 39/ 3 osid 39/ 4
[706]:BWREQ_3P 950542455 8520-usecs bytes:7992 req_id:794 sid:39/ 3 psid 39/ 3 osid 39/ 2
[706]:BWREQ_3P 950542455 8520-usecs bytes:7992 req_id:794 sid:39/ 3 psid 39/ 3 osid 39/ 3
[707]:GRANT 950543936 1481-usecs bytes:533 req_id:794 sid:39 chan:2
[708]:GRANT 950543954 18-usecs bytes:533 req_id:794 sid:39 chan:3
[709]:PG 950543957 3-usecs bytes:6942 req_id:794 sid:39 chan:3
[710]:GRANT 950543971 14-usecs bytes:541 req_id:794 sid:39 chan:4
US BW request for 72 bytes on ch 4
US BW Granted after 575 usecs on ch 4
9520 bytes requested
1803 bytes issued on 3 USs
Pending Grant
Piggyback BW Request

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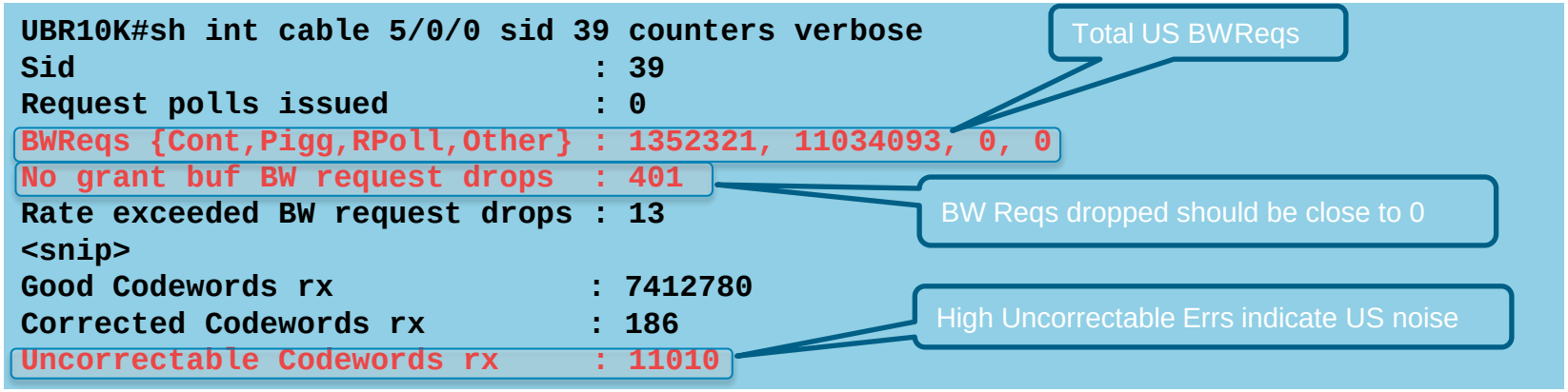
1.c – SID Tracker

Sid tracker stats

- Sid counters

```
UBR10K#sh int cable 5/0/0 sid 39 counters verbose
Sid                              : 39
Request polls issued             : 0
BWReqs {Cont,Pigg,RPoll,Other}   : 1352321, 11034093, 0, 0
No grant buf BW request drops    : 401
Rate exceeded BW request drops   : 13
<snip>
Good Codewords rx                : 7412780
Corrected Codewords rx           : 186
Uncorrectable Codewords rx       : 11010
```



- For throughput >= 40M

  2 SID clusters with 2 max request per sid

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1.c - Service Flow Segments

Deep dive in to US slow stats

```
UBR10K2# show int cable 5/0/0 service-flow 95 verbose

Sfid                                              : 95
Mac Address                                       : 0023.be50.e628
Type                                              : Primary
Direction                                 : Upstream
Current State                                     : Active
Current QoS Indexes [Prov, Adm, Act]      : [4, 4, 4]
<snip>
US Bonded                                 : YES
Upstream Bonding Group                            : UBG-257
Transmit Channel Set                              : 0xE
Sid Cluster                                       : SC-0, Sid [ 39 39 39 ]
Segments Valid                                    : 19692352
Segments Discarded                                : 0
Segments Lost                                     : 0
SID Cluster Switching Information
Total Bytes Requested                             : 0
Total Time                                        : 0
Outstanding Bytes                                 : 0
Max Requests                                      : 1
Classifiers: NONE
```

USCB modem

No Lost or discarded Segments

Show cable modem <mac/ip> service-flow verbose can be used for same stats

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1.c - Bonding group counters

Look for Available Bandwidth

```
UBR10K2#show int cable 5/0/0 upstream bonding-group
Cable5/0/0: Upstream Bonding Group 257
     74819 packets input, 4663782 octets input
     Segments: 74859 valid, 0 discarded, 0 lost
     Reserved Bandwidth Max : 0 bits/sec
     Reserved Bandwidth     : 0 bits/sec
     Available Bandwidth    : 7680000 bits/sec
     Total Service Flows On This Bonding Group: 1
```

Bonding Group number

Bonding Group BW Stats

Look for drops in scheduler queues

```
UBR10K2#show int cable 5/0/0 mac-scheduler 1
     DOCSIS 1.1 MAC scheduler for Cable5/0/0/U1: rate 2560000
     wfq:None
     Queue[Rng Polls] 0/128, 0 drops, flows 0 fs_demand_ms 0, max 1
     Queue[CIR Grants] 0/256, 0 drops, flows 0 fs_demand_ms 0, max 1
     Queue[BE(7) Grants] 0/128, 0 drops, flows 0 fs_demand_ms 0, max 0
     Queue[BE(6) Grants] 0/128, 0 drops, flows 0 fs_demand_ms 0, max 0
     Queue[BE(5) Grants] 0/128, 0 drops, flows 0 fs_demand_ms 0, max 0
     Queue[BE(4) Grants] 0/128, 0 drops, flows 0 fs_demand_ms 0, max 0
     Queue[BE(3) Grants] 0/128, 2305 drops, flows 0 fs_demand_ms 0, max 0
     Queue[BE(2) Grants] 0/128, 0 drops, flows 0 fs_demand_ms 0, max 0
     Queue[BE(1) Grants] 0/128, 0 drops, flows 0 fs_demand_ms 0, max 0
     Queue[BE(0) Grants] 0/128, 0 drops, flows 0 fs_demand_ms 0, max 2
     BG pending grant list entries: 0
     <snip>
     Avg upstream channel utilization : 1%
```

Individual US BW

Drops in BE flow

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Agenda

- CMTS Based Services Evolution
- Troubleshooting High Speed Data
  - DOCSIS 3.0 DS and US Channel Bonding Issues
- Troubleshooting Voice Service
  - Troubleshooting Voice Subscriber Issues
- Troubleshooting L2VPN BSoD
- Q & A
- Summary

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PacketCable™

The PacketCable architecture defines a platform to deliver Voice-over-Internet Protocol (VoIP) telephone service over a DOCSIS cable network

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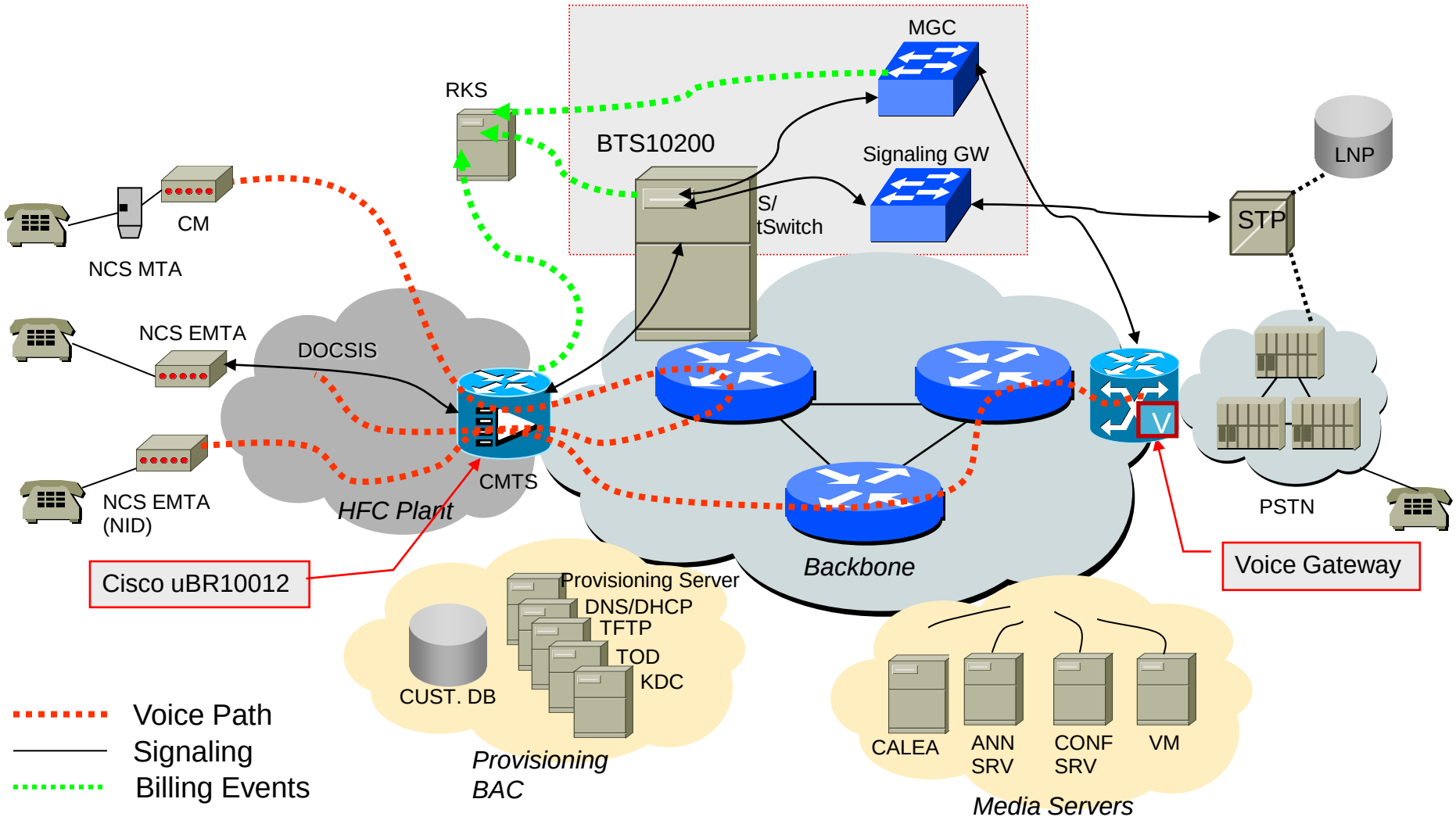
PacketCable™ Reference Architecture



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Common Voice Subscriber Issues

- 1 - No dial tone
  - 1.a - EMTA not registered
  - 1.b - Signaling flow not present
  - 1.c - High upstream utilization
- 2 - No audio and One way audio
  - 2.a - Gate establishment issues
  - 2.b - Dynamic service flow establishment issues
  - 2.c - Other possible issues
    - Not enough BW for DS
    - High US utilization
    - Low SNR in HFC
- 3 - Choppy audio
  - 3.a – Service Flow Bandwidth Issues
  - 3.b – PXF drops

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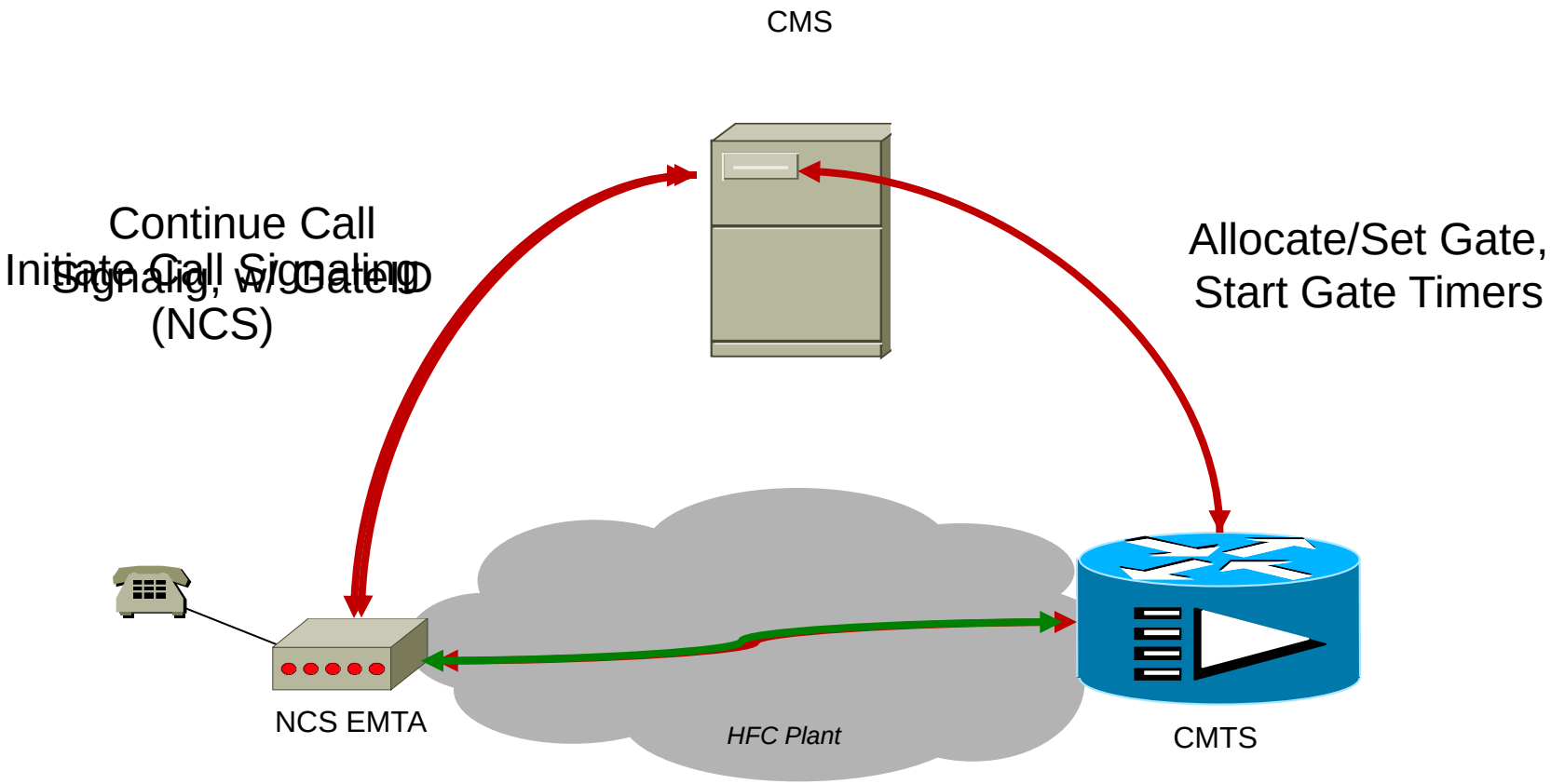
PacketCable™ DQoS



DSA, DSC with GateID

CMTS verifies DSX against Gate, stops Gate Timers

DOCSIS 1.1 UGS Active !

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1 - No Dial Tone

EMTA not registered and signaling flow issues

- 1.a - Check if the CM is online and MTA has IP add.

```
CMTS#show cable modem 0000.cadd.a3ef
MAC Address    IP Address      I/F       MAC          Prim RxPwr  Timing  Num
BPI
                                         State        Sid  (dB)   Offset  CPE
Enb
0000.cadd.a3ef 10.1.1.1        C8/0/2/U1 online       4    0.50  1515    1   N

show cable modem 0000.cadd.a3ef cpe
IP address      MAC address
14.80.82.141    0000.cadd.a3f0
```

CM is online

IP of MTA

- 1.b - Signaling flow not present

Issue “Show cable modem <mac-address> service-flow”

```
CMTS#show cable modem 0000.cadd.a3ef qos
Sfid  Dir Curr  Sid   Sched  Prio MaxSusRate  MaxBrst   MinRsvRate  Throughput
          State       Type
108   US  act   4     BE     1    2000000     3044      0           0
131   US  act   63    NRTPS  4    64000       3044      32000       197
109   DS  act   N/A   BE     1    6600000     12000     0           5
132   DS  act   N/A   BE     4    64000       96000     32000       110
```

nRTPS recommended for Signaling Flow

nRTPS signaling flow with priority 4

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1 - No Dial Tone

High US Utilization

- 1.c - Check for Avg. US utilization

  show int cabl 8/0/2 mac-scheduler 1

  DOCSIS 1.1 MAC

  scheduler for Cable8/0/2/U1

  <snip>

  Avg upstream channel utilization : 96%

- Many things needs to be checked on BTS/CA

  Outside the scope

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2 - No audio and One way audio

2.a - Gate establishment checking

- show packetcable gate summary

```
CMTS#show packetcable gate su
GateID    i/f     SubscriberID   GC-Addr        State     Type  SFID(us)
SFID(ds)
6576    Ca6/1/0   14.80.82.141   14.80.85.36    COMMIT    DQoS  91       92

22940   Ca6/1/0   14.80.82.144   14.80.85.36    COMMIT    DQoS  93       94

Total number of  gates = 2
Total Gates committed(since bootup or clear counter) = 17
```

Other possible states : ALLOC, AUTH, RSVD,INVLD and UNKWN

Gate has to be in COMMIT state

- Debugs needed to check gate establishment
  - Debug packetcable subscriber <mta-ip> verbose
  - Debug packetcable gate database
  - Debug packetcable gate control
  - Debug packetcable gate docsis-mapping
  - Debug packetcable gate commit

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2.b – Service Flow establishment

DSX messages

- DSX messages for dynamic service flow establishment
- Debugs for DSX messages and verification

  debug cable mac-address <cm mac> verbose

  debug cable tlv

  debug cable qos

  debug cable dynsrv

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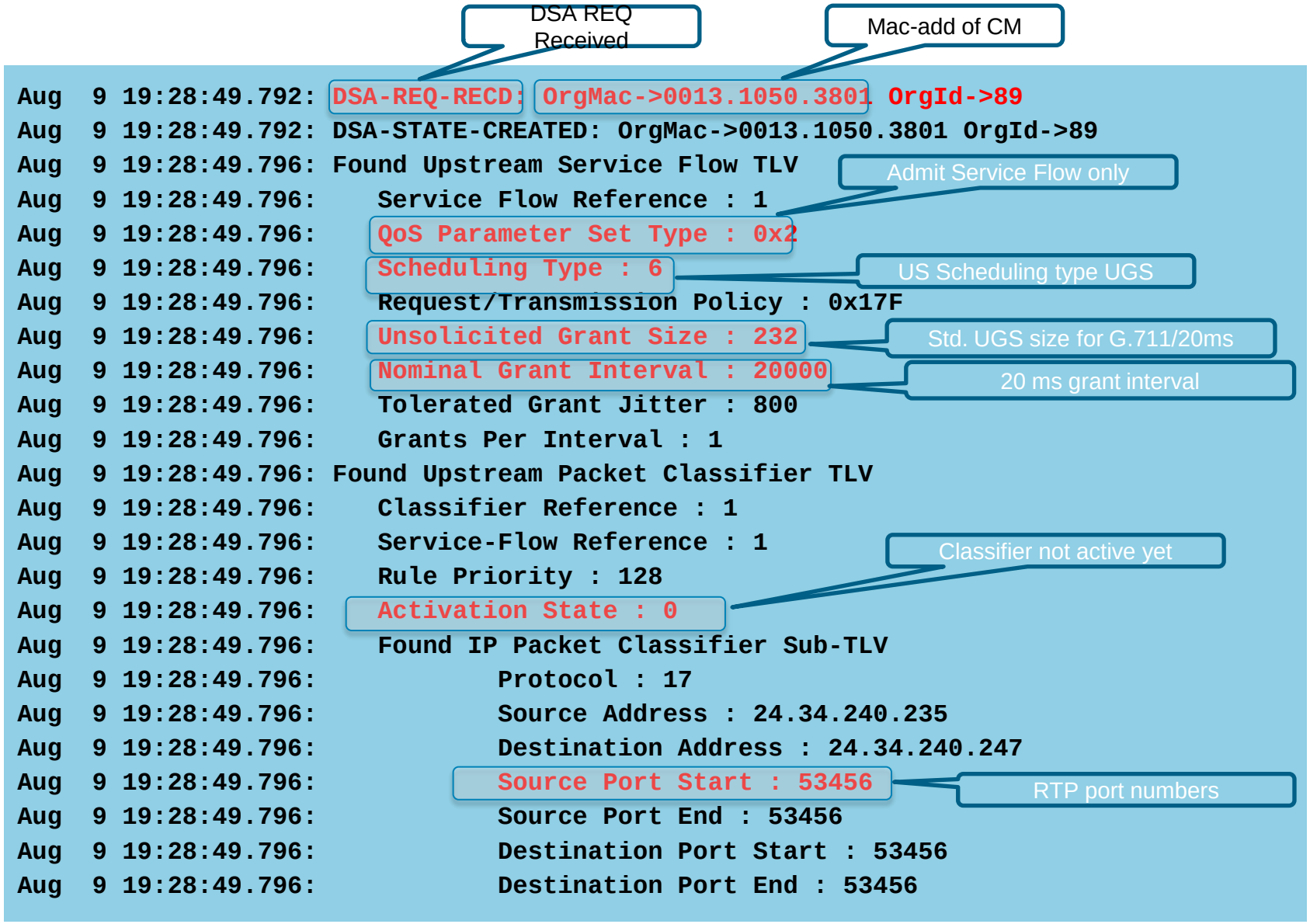
2.b - Dynamic service flow- sample debugs




```
Aug  9 19:28:49.792: DSA-REQ-RECD: OrgMac->0013.1050.3801 OrgId->89
Aug  9 19:28:49.792: DSA-STATE-CREATED: OrgMac->0013.1050.3801 OrgId->89
Aug  9 19:28:49.796: Found Upstream Service Flow TLV
Aug  9 19:28:49.796:    Service Flow Reference : 1
Aug  9 19:28:49.796:    QoS Parameter Set Type : 0x2
Aug  9 19:28:49.796:    Scheduling Type : 6
Aug  9 19:28:49.796:    Request/Transmission Policy : 0x17F
Aug  9 19:28:49.796:    Unsolicited Grant Size : 232
Aug  9 19:28:49.796:    Nominal Grant Interval : 20000
Aug  9 19:28:49.796:    Tolerated Grant Jitter : 800
Aug  9 19:28:49.796:    Grants Per Interval : 1
Aug  9 19:28:49.796: Found Upstream Packet Classifier TLV
Aug  9 19:28:49.796:    Classifier Reference : 1
Aug  9 19:28:49.796:    Service-Flow Reference : 1
Aug  9 19:28:49.796:    Rule Priority : 128
Aug  9 19:28:49.796:    Activation State : 0
Aug  9 19:28:49.796:    Found IP Packet Classifier Sub-TLV
Aug  9 19:28:49.796:            Protocol : 17
Aug  9 19:28:49.796:            Source Address : 24.34.240.235
Aug  9 19:28:49.796:            Destination Address : 24.34.240.247
Aug  9 19:28:49.796:            Source Port Start : 53456
Aug  9 19:28:49.796:            Source Port End : 53456
Aug  9 19:28:49.796:            Destination Port Start : 53456
Aug  9 19:28:49.796:            Destination Port End : 53456
```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2.b - Sample debugs..contd..

```
Aug  9 19:28:49.796: Found Downstream Service Flow TLV
Aug  9 19:28:49.796:    Service Flow Reference : 2
Aug  9 19:28:49.796:    QoS Parameter Set Type : 0x2
Aug  9 19:28:49.796:    Traffic Priority : 5
Aug  9 19:28:49.796:    Maximum Sustained Traffic Rate : 87200
Aug  9 19:28:49.796:    Maximum Traffic Burst : 1522
Aug  9 19:28:49.796:    Minimum Reserved Traffic Rate : 87200
Aug  9 19:28:49.796:    Minimum Reserved Rate Packet Size : 218
Aug  9 19:28:49.796: Found Downstream Packet Classifier TLV
Aug  9 19:28:49.796:    Classifier Reference : 2
Aug  9 19:28:49.796:    Service-Flow Reference : 2
Aug  9 19:28:49.796:    Rule Priority : 128
Aug  9 19:28:49.796:    Activation State : 0
Aug  9 19:28:49.796:    Found IP Packet Classifier Sub-TLV
Aug  9 19:28:49.796:            Protocol : 17
Aug  9 19:28:49.796:            Source Address : 24.34.240.247
Aug  9 19:28:49.796:            Destination Address : 24.34.240.235
Aug  9 19:28:49.796:            Destination Port Start : 53456
Aug  9 19:28:49.796:            Destination Port End : 53456
Aug  9 19:28:49.796: Auth Block:
Aug  9 19:28:49.796: 0x0000: 01 06 01 04 00 00 14 3E
Aug  9 19:28:49.796: Sfref = 1, SFID = 103 <- Service Flow IDs assigned by CMTS
Aug  9 19:28:49.796: Sfref = 2, SFID = 104
Aug  9 19:28:49.796: Cfr-ref = 1, CFID = 33, SF-ref 1, SFID 103
Aug  9 19:28:49.796: Cfr-ref = 2, CFID = 34, SF-ref 2, SFID 104
Aug  9 19:28:49.796: Added Auth Block(633A2828) len=14
Aug  9 19:28:49.796: DSA-RSP-SENT: CM->0013.1050.3801 TranscId->89 ConfCode->0
Aug  9 19:28:49.896: DSA-ACK-RECD: OrgMac->0013.1050.3801 OrgId->89 ConfCode->0
Aug  9 19:28:50.196: DSA-REQ End. Transaction over-T8 timer expired. OrgMac->0013.1050.3801
                     OrgId->89
Aug  9 19:28:50.196: DYN-SRV-STATE-DESTROYED : OrgMac->0013.1050.3801 OrgId->89
```

Admit Service Flow only

DS service flow with high priority

DQOS Gate ID contained here

SFID assigned for US and DS

DSA Response sent and ACK received

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2.b - DSX message stats

- Use “show controller cable x/y/z”

```
Cable5/0/0 Downstream is up
  Frequency 615.0000 MHz, Channel Width 6 MHz, 256-QAM, Symbol Rate 5.360537 Msps
  FEC ITU-T J.83 Annex B, R/S Interleave I=32, J=4
  Downstream channel ID: 119
<snip>
  Dynamic Services Stats:
  DSA: 0  REQs  21368 RSPs  0 ACKs
  0 Successful DSAs  41 DSA Failures
  DSC: 0  REQs  24761 RSPs  0 ACKs
  0 Successful DSCs  0 DSC Failures
  DSD:  38 REQs  21335 RSPs
  0 Successful DSDs  37 DSD Failures
  DBC: 0 REQs  0 RSPs(Rcvd)  0 ACKs
  0 Successful DBCs  0 DBC Failures  0 DBC Partial
  0 DBC Protocol Violations
```

Only RSPs captured under DS

DSA failures has to be 0

DSC failures has to be 0

DSD failures has to be 0

- Use “show controller cable x/y/z upstream j” for DSA, DSC and DSD Request stats

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2.c - Other possible issues

- Not enough bandwidth available for DS
  - Issue “show interface cable x/y/z downstream”
    - Look for “Total downstream reserved/reservable bandwidth”
- High CPU for PRE and/or LC
  - Issue “show proc cpu” on PRE and on affected LC
  - Excessive SNMP polling
- Higher Upstream channel utilization
  - Issue “show interface cable x/y/z mac-schedular j”
    - Look for “Avg upstream channel utilization” and other flow related BW reservation
  - Uncorrectable FEC and CRC errors should be between 1-5%
- Low SNR in HFC network
  - Issue “show controller cable x/y/z”
    - Look for “US phy MER(SNR)_estimate for good packets” around 25db+

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3- Choppy audio Issues

3.a – Service Flow Bandwidth issues

- Typically happens because of dropped packets
- Check for dynamic service flows for eMTA and packet count
- Use “show cable modem <mac/ip-add> service-flow” Or

show interfaces c5/0/0 service-flow | inc dyn | inc eeb6

Sfid	Sid	Mac Address	QoS Param Index			Type	Dir	Curr	Active
			Prov	Adm	Act			State	Time
142	77	0000.cad6.eeb6	0	10	10	dyn(S)	US	act	22:11
143	N/A	0000.cad6.eeb6	0	11	11	dyn(S)	DS	act	22:11

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3.a - Choppy Voice – Show service-flow

```
CMTS#show int cable 5/0/0 service-flow  142 verbose
Sfid                                    : 142
Mac Address                             : 0000.cad6.eeb6
Type                                    : Secondary(Dynamic)
Direction                               : Upstream
Current State                           : Active
Current QoS Indexes [Prov, Adm, Act]    : [0, 10, 10]
Active Time                             : 23:16
Sid                                     : 77
Admitted QoS Timeout                    : 200 seconds
<snip>
Current Throughput                      : 87200 bits/sec, 50 packets/sec
Application Priority                    : 3
Classifiers:
Classifier Id                       : 78
Service Flow Id                     : 142
CM Mac Address                      : 0000.cad6.eeb6
Direction                           : upstream
Activation State                    : active
Classifier Matching Priority        : 128
PHSI                                : 0
Number of matches                   : -
IP Classification Parameters:
        IP Source Address           : 14.80.82.141
        Source IP Address Mask      : 255.255.255.255
        Destination IP Address      : 14.80.82.7
        Destination IP Address Mask : 255.255.255.255
```

US dynamic service flow

US Service Flow

218 bytes@50 PPS=87200 bps

Source IP of US flow

Destination IP of US flow

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3.a - Choppy Voice – Show service-flow

```
CMTS#show int cable 5/0/0 service-flow  143 verbose
Sfid                                    : 143
Mac Address                             : 0000.cad6.eeb6
Type                                    : Secondary(Dynamic)
Direction                               : Downstream
Current State                           : Active
Current QoS Indexes [Prov, Adm, Act]    : [0, 11, 11]
Active Time                             : 24:02
Sid                                     : N/A
Traffic Priority                        : 5
Minimum Reserved Rate                   : 87200 bits/sec
Admitted QoS Timeout                    : 200 seconds
<snip>
Current Throughput                      : 87254 bits/sec, 50 packets/sec
Application Priority                    : 3
Classifiers:
Classifier Id                       : 79
Service Flow Id                     : 143
CM Mac Address                      : 0000.cad6.eeb6
Direction                           : downstream
Activation State                    : active
Classifier Matching Priority        : 128
PHSI                                : 0
Number of matches                   : 72112
IP Classification Parameters:
        IP Source Address           : 14.80.82.7
        Source IP Address Mask      : 255.255.255.255
        Destination IP Address      : 14.80.82.141
        Destination IP Address Mask : 255.255.255.255
```

DS dynamic service flow

DS Service Flow

High Priority for DS flow

Min Reserve rate

Current throughput

Source IP of DS flow

Destination IP of DS flow

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3.a - Choppy Voice – Show service-flow

Check service flow drops and Bits/Sec

- **show interfaces c5/0/0 service-flow 142 counters**

Sfid	Packets	Bytes	PacketDrops	Bits/Sec	Packets/Sec
142	73563	16036734	0	87072	49

- **show interfaces c5/0/0 service-flow 143 counters**

Sfid	Packets	Bytes	PacketDrops	Bits/Sec	Packets/Sec
143	73797	16087746	0	87200	50

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3.b - Choppy Voice – PXF drops

Check for DS pxf drops

- Get the DS pxf_qid using command

  Show cable modem <mac/ip address> service-flow

DOWNSTREAM SERVICE FLOW DETAIL:

SFID	RP_SFID	**QID**	Flg	Policer		Scheduler		FrwdIF
				Xmits	Drops	Xmits	Drops	
143	37756	136278		14926	0	14926	0	Mo1/1/0:0

- Use “Show pxf cpu queue <qid>” and look for

  Drops (tail/random/max_threshold) : 0/0/0

  Drops (no_pkt_handle/buffer_low) : 0/0

  WRED (weight/avg_smaller) : 0/0

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Agenda

- CMTS Based Services Evolution
- Troubleshooting High Speed Data
  - DOCSIS 3.0 DS and US Channel Bonding Issues
- Troubleshooting Voice Service
  - Troubleshooting Voice Subscriber Issues
- Troubleshooting L2VPN BSoD
- Q & A
- Summary

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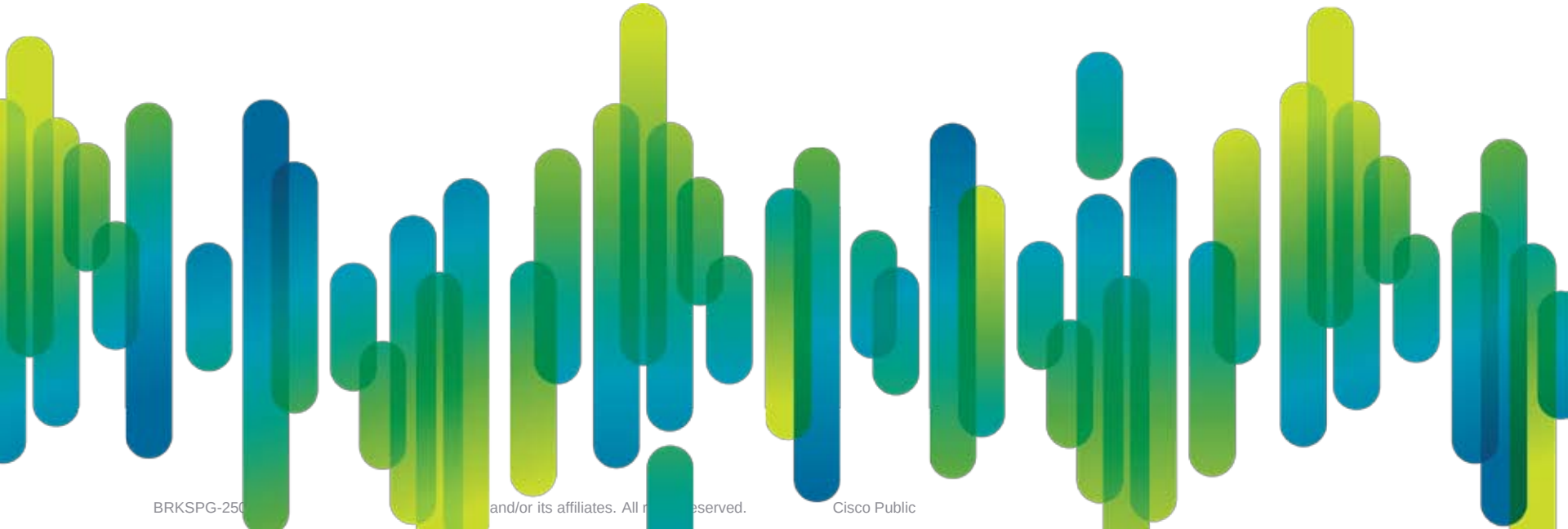
Troubleshooting L2VPN Business Service over DOCSIS (BSoD)



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Business Services over DOCSIS (BSoD)

- CMTS – Traditional High Speed Data vs newer BSoD usage
- HFC plant typically under-utilized in business hours
- Business services over HFC can maximize Return of Investment (ROI)
- CableLabs standardized Layer2 VPN Business Services over DOCSIS (BSoD)
- Multiple BSoD flavors
  - Transparent LAN Services over DOCSIS – Cisco Proprietary
  - Dot1Q based L2VPN BSoD – CableLabs Standard
  - MPLS based L2VPN BSoD – CableLabs Compliant

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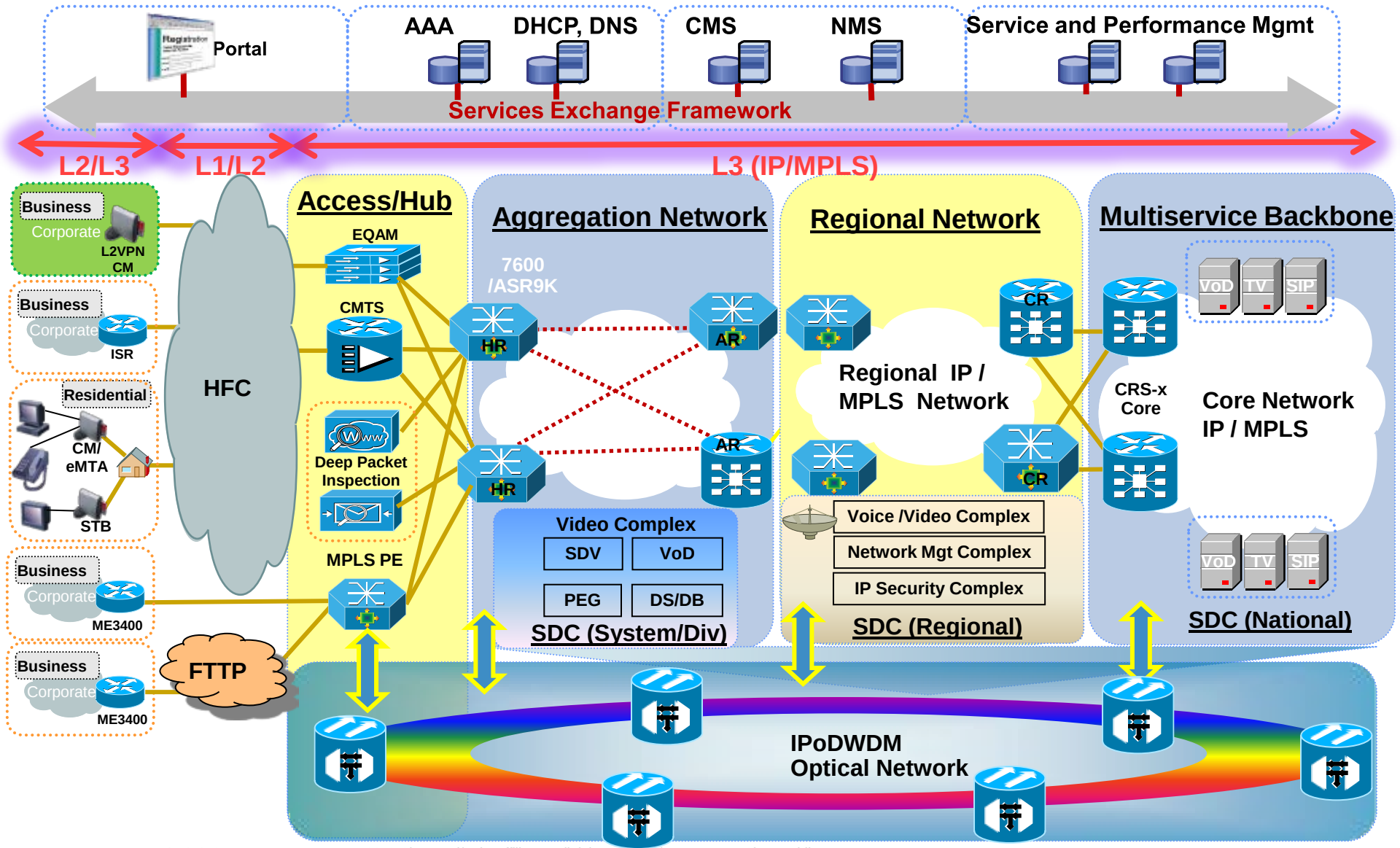
Cable Multi Service Networks



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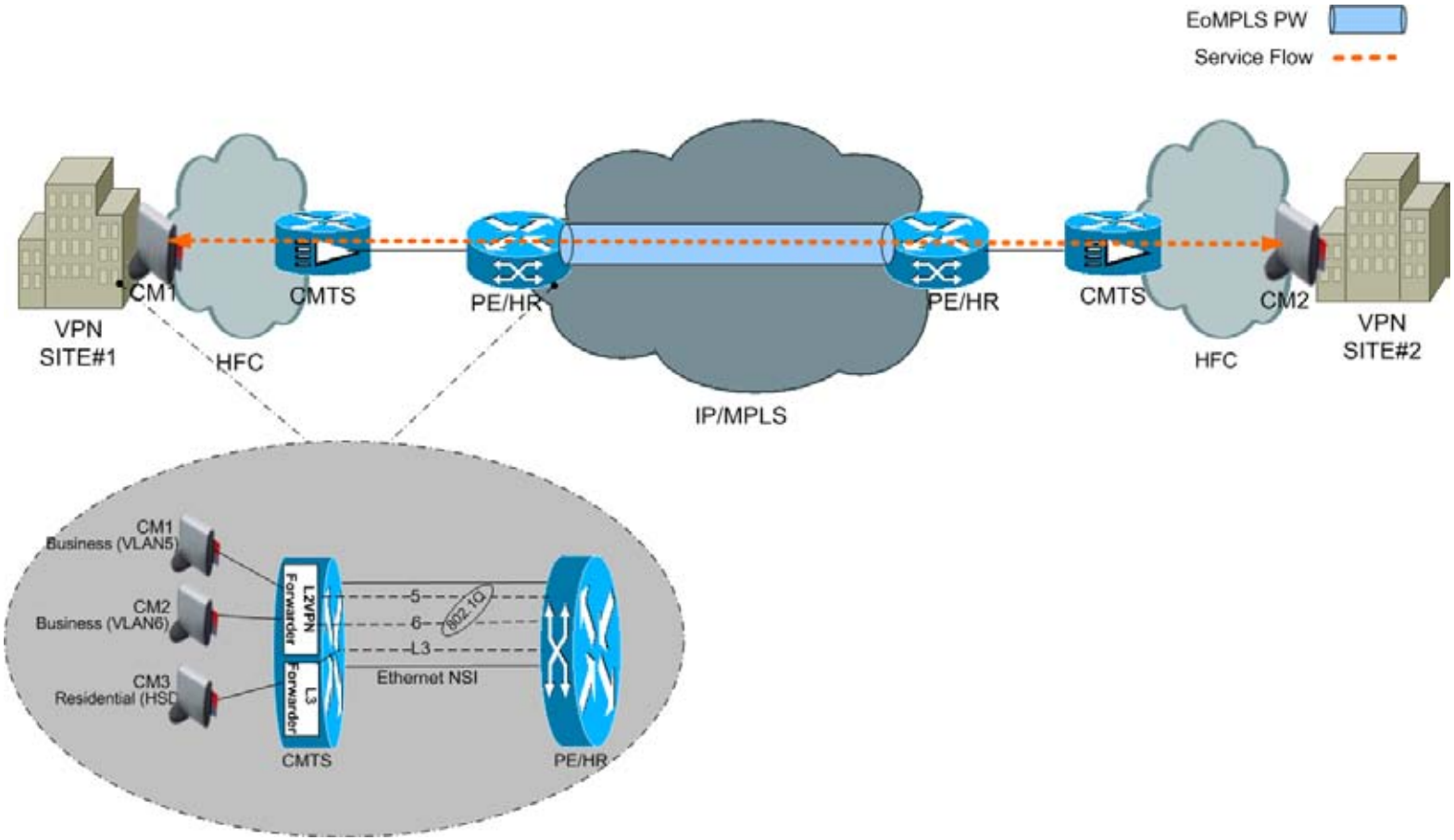
Transparent LAN Service (TLS) over DOCSIS



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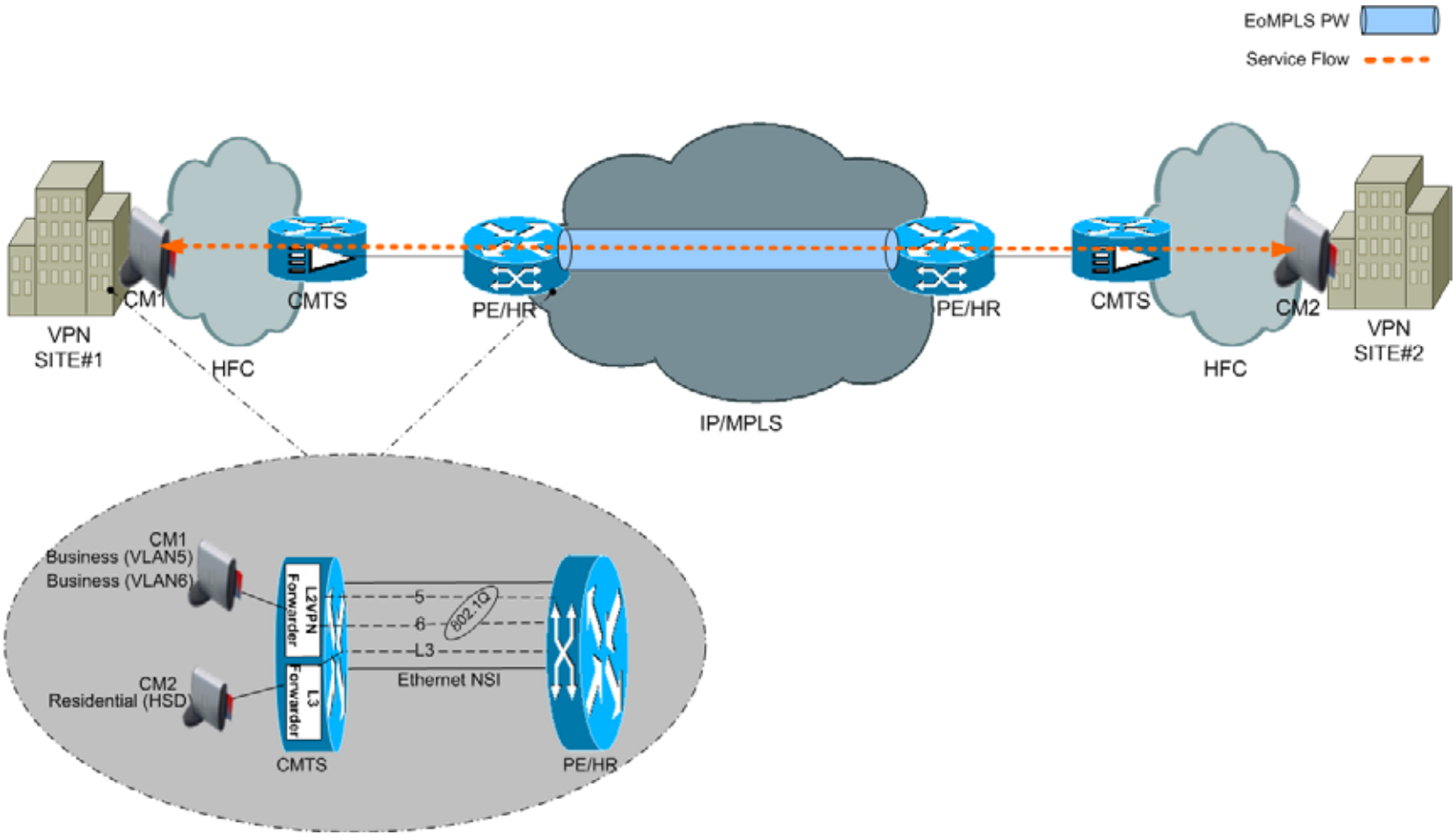
Dot1Q based L2VPN BSoD



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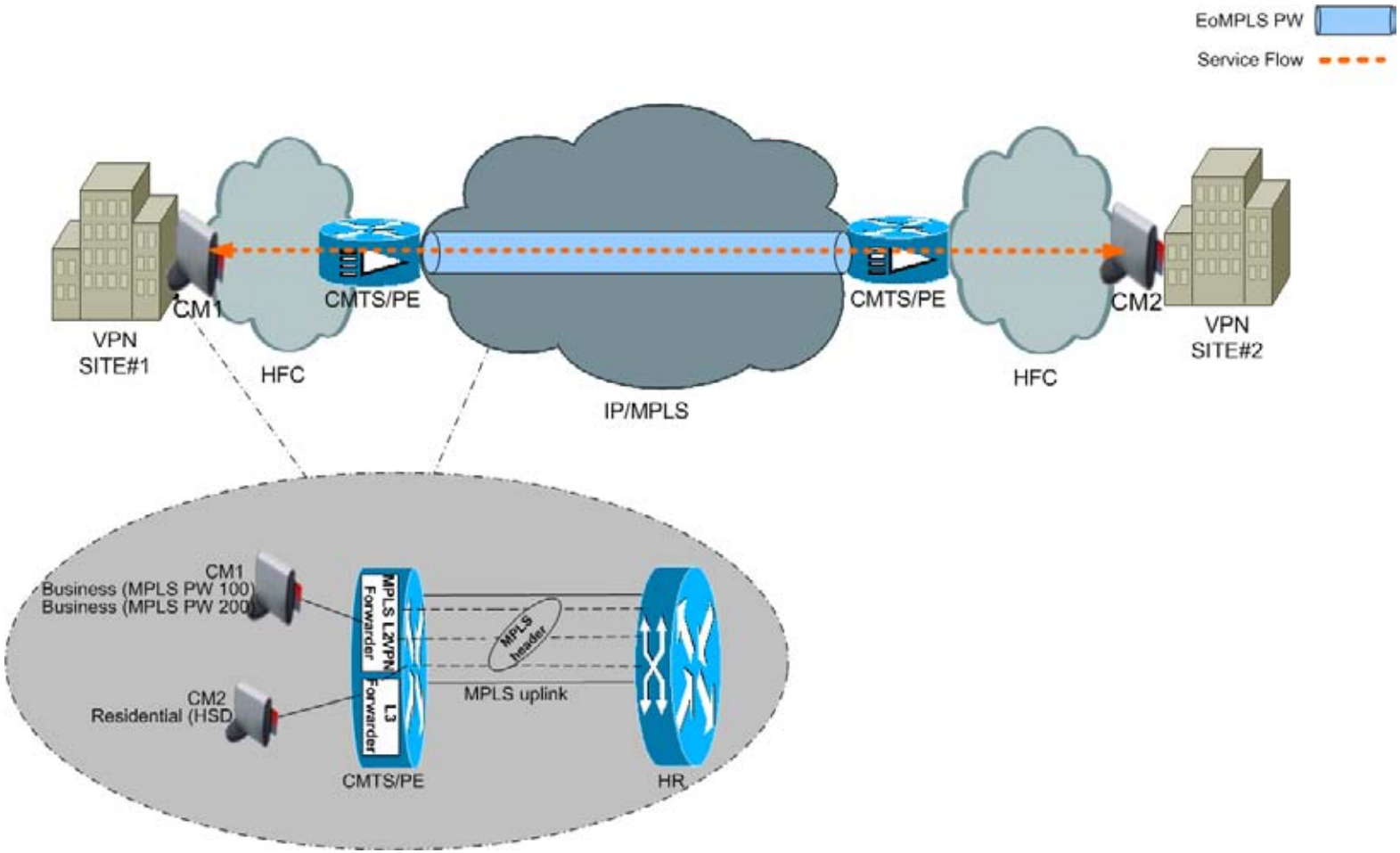
MPLS based L2VPN BSoD



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Troubleshooting L2VPN BSoD

1. Verify Cable Modem is Online(pt)
2. Verify whether the CM is registered as L2VPN
3. Verify whether the MPLS pseudowire (PW) is UP

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1. Verify CM is Online

- TLS
- DOt1Q BSOD
- MPLS BSoD

```
CMTS-uBR10k#sh cable modem 0022.3a61.7bcf
Load for five secs: 0%/0%; one minute: 0%; five minutes: 0%
Time source is NTP, 19:29:47.278 EDT Wed Mar 24 2010
                                                                      D
MAC Address    IP Address     I/F         MAC            Prim RxPwr  Timing Num I
                                          State          Sid  (dBmv) Offset CPE P
0022.3a61.7bcf 17.101.75.100  C5/1/0/U0   offline        9    0.75   1183   0   N
```

- Possible reasons for CM to be offline

  1a. Basic DOCSIS issues

  - DHCP, TFTP, ToD and DOCSIS layer issues

  1b. Feature not supported on CMTS Software Version

  - TLS: 12.2(15)BC or later crypto releases
  - Dot1Q: 12.2(33)SCA or later crypto releases
  - MPLS: 12.2(33)SCC or later crypto releases

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- 1c. Feature not supported on CM software version

```
CMTS-uBR10k#sh cable modem 0022.3a61.7bcf verbose [Snippet]
sysDescr                      : Cisco DOCSIS Cable Modem<<HW_REV: 2.1; VENDOR:
Cisco; BOOTR: 2.1.6d; SW_REV: v2.0.2r1256-100222; MODEL: DPC2100R2>>
Modem Status                  : {Modem= online(pt), Security=assign(tek)}
Security Capabilities         : {Priv=BPI+, EAE=N, Key_len=56}
L2VPN Capabilities            : {L2VPN=Y, eSAFE=N}
Sid/Said Limit                : {Max US Sids=16, Max DS Saids=15}
Optional Filtering Support    : {802.1P=Y, 802.1Q=Y, DUT=Y}
```

- 1d. CMTS not configured for L2VPN BSoD

```
CMTS-uBR10k#sh cable logging layer2events
Cable logging: LAYER2EVENTS Enabled
002073: Mar 24 19:52:16.714 EDT: %UBR10000-6-CM_OFFLINE_WITH_MPLS_L2VPN_NOT_ENABLE:
DOCSIS MPLS L2VPN not enabled, sending CM 0022.3a61.7bcf offline
```

- 1e. Incorrect L2VPN encoding in the CM configuration file

```
Debug message:CMTS L2 VPN debugging is on
002134: Mar 24 19:54:59.973 EDT: cmts_docsis_l2vpn_add sanity failed: mac
0022.3a61.7bcf, sid 16,vlanid 0,vpnid 2020
```

- Cable Modem is online(pt)

```
CMTS-uBR10k#sh cable modem 0022.3a61.7bcf
MAC Address    IP Address     I/F          MAC            Prim RxPwr  Timing Num I
                                           State          Sid  (dBmv) Offset CPE P
0022.3a61.7bcf 17.101.75.100  C5/1/0/U0    online(pt)     9    17.75  1183   0   N
```


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2. Verify whether CM is registered as L2VPN

Dot1Q BSoD

```
CMTS-uBR10k#sh cable l2-vpn xconnect dot1q-
vc-map 0022.3a61.7bcf verbose
MAC Address             : 0022.3a61.7bcf
Prim Sid                : 17
Cable Interface         : Cable5/1/0
L2VPNs provisioned      : 1
DUT Control/CMIM        : Enable/0x8000FFFF
VPN ID                  : 0234560002
L2VPN SAID              : 12302
Upstream SFID Summary   : 29
Upstream SFID [29   ]   : SID 17   UserPrio 3
Downstream CFRID[SFID]: Primary SF
CMIM                    : 0x60
Ethernet Interface      : GigabitEthernet3/1/0
DOT1Q VLAN ID           : 5
Total US pkts           : 0
Total US bytes          : 0
Total US pkt Discards   : 0
Total US byte Discards: 0
Total DS pkts           : 0
Total DS bytes          : 0
Total DS pkt Discards   : 0
Total DS byte Discards: 0
```

MPLS BSoD

```
CMTS-PE#sh cable l2-vpn xconnect mpls-vc-
map 0022.3a61.7bcf verbose
MAC Address             : 0022.3a61.7bcf
Prim Sid                : 16
Cable Interface         : Cable5/1/0
L2VPNs provisioned      : 1
DUT Control/CMIM        : Enable/0x8000FFFF
VPN ID                  : 2020
L2VPN SAID              : 12296
SAII                    : 000007D1
TAII                    : 000007D1
Upstream SFID Summary   : 27
Upstream SFID [27   ]   : SID 16   MPLS-EXP 4
Downstream CFRID[SFID] Summary: Primary SF
CMIM                    : 0x60
MPLS PEER IpAddress     : 99.1.1.22
MPLS PW VCID            : 2001
MPLS PW TYPE            : Ethernet
MPLS PW Circuit ID      : Bu254:2001
MPLS PW Remote State    : Down
MPLS PW Local  State    : UP
Total US pkts           : 0
Total US bytes          : 0
Total US pkt Discards   : 0
Total US byte Discards: 0
Total DS pkts           : 0
Total DS bytes          : 0
Total DS pkt Discards   : 0
Total DS byte Discards: 0
```


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2b. Verify L2VPN Parallel eXpress Forwarding (PXF)

Dot1Q BSoD

```
CMTS-uBR10k#sh pxf cable l2-vpn
0022.3a61.7bcf
Load for five secs: 0%/0%; one minute: 0%;
five minutes: 0%
Time source is NTP, 12:02:28.927 EDT Thu Mar
25 2010

MAC Address 0022.3a61.7bcf
  upstream index 13, us_sid 17, vlan_hdr
0x6005,CM MAC addr 0022.3a61.7bcf,
    vcci 142, flags 0x0, esmac
0000.0000.0000, cmim 0x0
    packets 0, bytes 0, discard packets 0,
discard bytes 0
  downstream index 13, vcci 145, l2vpn_said
17 ds_classif_result 0x8809E
    packets 0, bytes 0 discard packets 0,
discard bytes 0
```

MPLS BSoD

```
CMTS-PE#sh pxf cable l2-vpn atom mac
0022.3a61.7bcf
ATOM L2VPN Information for CM 0022.3a61.7bcf
Start:
 DOCSIS ATOM L2VPN Upstream Information:
 ATOM Enable SID     : 16
 vcci maptable flags : 0x4000
 atom_us_index       : 30
 upstream index      : 30
 us_sid              : 16
 CM MAC addr         : 0022.3a61.7bcf
 vcci_out            : 0x0
 mac_rew_index       : 0x0
 rew_extension       : 0x2F
 ingress_flags       : 0x40
 upstream punt       : Disabled
 CM MAC table flags  : 0x8000
 esmac               : 0000.0000.0000
 cmim                : 0x0
 Forward packets     : 0
 Forward bytes       : 0
 Discard packets     : 0
 Discard bytes       : 0
 DOCSIS ATOM L2VPN Downstream Information:
 Downstream index    : 2001
 flags               : 0x1
 l2vpn_said          : 16
 ds_classif_result   : 0x8809D
 Forward packets     : 0
 Forward bytes       : 0
 Discard packets     : 0
 Discard bytes       : 0
```


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3. Verify whether the MPLS PW is UP

- DOt1Q BSOD
- MPLS BSoD

```
Dot1Q-PE#sh mpls l2transport vc 2001
Load for five secs: 2%/1%; one minute: 2%; five minutes: 2%
Time source is NTP, 14:14:06.941 EDT Thu Mar 25 2010
Local intf     Local circuit              Dest address    VC ID      Status
-------------  -------------------------- --------------- ---------- -------
---
Gi4/23.1       Eth VLAN 11                99.1.1.22       2001       DOWN
```

```
CMTS-PE#sh mpls l2transport vc 2001
Load for five secs: 0%/0%; one minute: 0%; five minutes: 0%
Time source is NTP, 14:17:52.398 EDT Thu Mar 25 2010
Local intf     Local circuit              Dest address    VC ID      Status
-------------  -------------------------- --------------- ---------- -------
---
Bu254          DOCSIS 2001                99.1.1.22       2001       DOWN
```

Possible reasons for MPLS PW down

- No Label Switch Path (LSP) established
- No targeted LDP session
- Interface MTU mismatch

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3a. Verify whether the MPLS PW is UP

Dot1Q BSOD

```
Dot1Q-PE#sh mpls l2transport vc 2001 detail
Local interface: Gi4/23.1 up, line protocol up, Eth VLAN 11 up
  Interworking type is Ethernet
  Destination address: 99.1.1.22, VC ID: 2001, VC status: up
    Output interface: Te1/1, imposed label stack {51 64}
    Preferred path: not configured
    Default path: active
    Next hop: 11.1.0.5
  Create time: 4w0d, last status change time: 00:00:57
  Signaling protocol: LDP, peer 99.1.1.22:0 up
    Targeted Hello: 99.1.1.12(LDP Id) -> 99.1.1.22, LDP is UP
    Status TLV support (local/remote)   : enabled/supported
      LDP route watch                   : enabled
      Label/status state machine        : established, LruRru
      Last local dataplane   status rcvd: No fault
      Last local SSS circuit status rcvd: No fault
      Last local SSS circuit status sent: No fault
      Last local  LDP TLV    status sent: No fault
      Last remote LDP TLV    status rcvd: No fault
      Last remote LDP ADJ    status rcvd: No fault
    MPLS VC labels: local 89, remote 64
    Group ID: local 0, remote 0
    MTU: local 4470, remote 4470
    Remote interface description:
  Sequencing: receive disabled, send disabled
  Control Word: Off (configured: autosense)
  SSO Descriptor: 99.1.1.22/2001, local label: 89
    SSM segment/switch IDs: 16465/8252 (used), PWID: 8204
  VC statistics:
    transit packet totals: receive 34063315, send 11784915
    transit byte totals:   receive 10849943060, send 1205412300
    transit packet drops:  receive 0, seq error 0, send 0
```


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3a. Verify whether the MPLS PW is UP

MPLS BSoD

```
CMTS-PE#sh mpls l2transport vc 2001 detail
Load for five secs: 0%/0%; one minute: 0%; five minutes: 1%
Time source is NTP, 20:29:41.852 EDT Wed Mar 24 2010

Local interface: Bu254 up, line protocol up, DOCSIS 2001 up
  Destination address: 99.1.1.22, VC ID: 2001, VC status: up
    Output interface: Gi3/1/0, imposed label stack {101 31}
    Preferred path: not configured
    Default path: active
    Next hop: 11.11.0.101
  Create time: 00:33:28, last status change time: 00:07:40
  Signaling protocol: LDP, peer 99.1.1.22:0 up
    Targeted Hello: 99.1.1.13(LDP Id) -> 99.1.1.22
    Status TLV support (local/remote)   : enabled/supported
      Label/status state machine        : established,
LruRru
      Last local dataplane   status rcvd: no fault
      Last local SSS circuit status rcvd: no fault
      Last local SSS circuit status sent: no fault
      Last local  LDP TLV    status sent: no fault
      Last remote LDP TLV    status rcvd: no fault
    MPLS VC labels: local 94, remote 31
    Group ID: local 0, remote 0
    MTU: local 1500, remote 1500
    Remote interface description:
  Sequencing: receive disabled, send disabled
  SSO Descriptor: 99.1.1.22/2001, local label: 94
    SSM segment/switch IDs: 8198/4100 (used), PWID: 4100
  VC statistics:
    packet totals: receive 23951, send 23951
    byte totals:   receive 2730414, send 2395100
    packet drops:  receive 0, seq error 0, send 0
```


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Troubleshooting MPLS L2VPN BSoD (Cont..)

Useful debug commands

- Debug cable l2-vpn
- Debug cable tlvs
- Debug cable mac-address
- Debug mpls l2transport vc status event

Note: Use caution when enabling above commands in production routers

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Summary

- Evolution of CMTS Based Services
- Common Data Service Issues and Troubleshooting
- Common VoIP Service issues
- L2VPN BSoD Variations and troubleshooting

“Effective troubleshooting will decrease downtime and increase customer satisfaction”

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CISCO

Acronyms/Abbreviations

- DOCSIS = Data-Over-Cable Service Interface Specification
- CMTS = Cable Modem Termination System
- DS = Downstream
- US = Upstream
- CM = Cable Modem
- NB = Narrowband (Traditional DOCSIS channel) or PC
- WB = Wideband
- M-CMTS = Modular CMTS
- PC = Primary Channel
- BG = Bonding Group
- QAM = Quadrature Amplitude Modulation
- PRE = Performance Routing Engine
- RP = Route Processor
- MAP = Mini-Slot Allocation Protocol
- MDD = MAC Domain Descriptor
- CGD = Channel Grouping Domain
- MC = Modular-Cable
- LC = Line Card
- MD = Mac Domain
- CIN = Converged Interconnect Network
- EQAM = Edge QAM
- UQAM = Universal [Edge] QAM
- SPA = Shared Port Adapter
- SIP = SPA Interface processor
- SFP = Small Form-Factor Pluggable
- GE = Gigabit Ethernet
- RF = Radio Frequency
- Guardian = 5x20 line card that runs MDD process

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Additional slides

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Agenda

- CMTS Based Services Evolution
- Troubleshooting High Speed Data
- Troubleshooting Voice Service
- Troubleshooting L2VPN BSoD
- Summary

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Mac Domain Descriptor Message (MDD)

Highlights…

- Introduced in DOCSIS 3.0
- Provides DS and US topology
- Transmitted every 2 seconds
  - On all PC and non-PC Channels
  - Modem must re-register if 3 consecutive MDD are missed
- Specifies the IP Provisioning mode
  - IPv4 only, IPv6 only, Dual Stack Mode (DPM) or Alternate Provisioning Mode (APM)
- Option for early authentication and encryption (EAE)
- MDD has to be “Valid”

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CM-STATUS Message

- Used by CM for RF side issues
- Controlled by the CMTS by using TLVs via MDD
- CM-STATUS events:

  Type 1- MDD timeout

  Type 2 - QAM/FEC lock failure

  Type 4 - MDD Recovery

  Type 5- QAM/FEC Lock

```
CM-STATUS Event Control
  Event Type Code:          MDD Timeout
  Event Holdoff Timer:      50 (20 ms) ticks
  Reports per Event         2
CM-STATUS Event Control
  Event Type Code:          QAM FEC failure
  Event Holdoff Timer:      50 (20 ms) ticks
  Reports per Event         2
```

- Use “Cable rf-change-trigger” global CLI to modify BG

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2.b - Link failure between CMTS and EQAM

```
UBR10K#show cable modem 001e.6bfb.057c
                                                                          D
MAC Address    IP Address     I/F          MAC            Prim RxPwr  Timing Num I
                                           State          Sid  (dBmv) Offset CPE P
001e.6bfb.057c 13.33.139.71   C7/0/0/U0    w-online(pt)   589  0.00   1763   0   N

May 2 22:56:44.410: %SPAWBCMTS-4-SFP_LNK_LOST:Modular-Cable 1/0/0, port 0 link
changed state to down
May 2 22:56:44.422: %LINK-3-UPDOWN: Interface Wideband-Cable 1/0/0:0 changed state
to down
May 2 22:56:47.410: %LINEPROTO-5-UPDOWN: Line protocol on Interface Wideband CMTS
SPA,  changed state to down
May 2 22:56:47.422: %LINEPROTO-5-UPDOWN: Line protocol on Interface Wideband-Cable
1/0/0:0,  changed state to down
May 2 22:56:50.047: %LINK-3-UPDOWN: Interface Modular-Cable 1/0/0:0,  changed state
to down
May 2 22:56:50.059: %LINEPROTO-5-UPDOWN: Line protocol on Interface Modular-Cable
1/0/0:0,  changed state to down

UBR10K#show cable fiber-node 10
Fiber-Node         Config Status
Fiber-Node 10
       downstream Modular-Cable 1/0/0:  0-3
       downstream Cable 7/0/0
FN Config Status: Configured (status flags = 0x01)
    MDD Status: Valid
UBR10K#show cable modem wideband
MAC Address    IP Address      I/F          MAC            Prim  RCC  MD-DS-SG/
                                            State          Sid   ID   MD-US-SG
```

SFP Link Lost between CMTS and EQAM

Modular-Cable interface went down

MDD is still valid but no CM w-online

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2. Per CM DS and US throughput verification

Show commands to be used

- Make sure CM is not in “Partial Service”
  - Status will be p-online for DS partial service in future IOS
- Show cable modem <mac/ip-add> service-flow
  - Look for throughput counter
- Show pxf cpu queue qid
  - VTMS QID applicable only for downstream
  - Look for Drops
- show cable modem ip-address qos
  - For IOS prior to 12.3(23)BC7

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2. show cable modem ip-address service-flow

```
UBR10K2#show cable modem 10.10.2.6 service-flow
SUMMARY:
MAC Address    IP Address     Host         MAC              Prim Num Primary    DS
                              Interface    State            Sid  CPE Downstream RfId
0023.be50.e628 10.10.2.6      C5/0/0/U0    w-online(pt)     28    0   Mo1/0/0:0  0

Forwarding Interface: Wideband-Cable 1/0/0:0
Sfid  Dir Curr  Sid   Sched  Prio MaxSusRate  MaxBrst   MinRsvRate  Throughput
          State       Type
100   US  act   28    BE     0    5000000      8192      0           846
101   DS  act   N/A   BE     0    101000000    3044      0           99000124

UPSTREAM SERVICE FLOW DETAIL:

SFID  SID   Requests   Polls      Grants     Delayed    Dropped    Packets
                                             Grants     Grants
100   28    0          0          13750      0          0          13740

DOWNSTREAM SERVICE FLOW DETAIL:

SFID  RP_SFID QID    Flg Policer                 Scheduler
                     Xmits      Drops      Xmits      Drops
101   33153   854    14318351   0          14131275   0

Flags Legend:
$: Low Latency Queue (aggregated)
@: Aggregated Best Effort Queue
```

Primary Sid of CM

Current throughput

PXF Qid for DS service flow

No Dropped or Delayed grants

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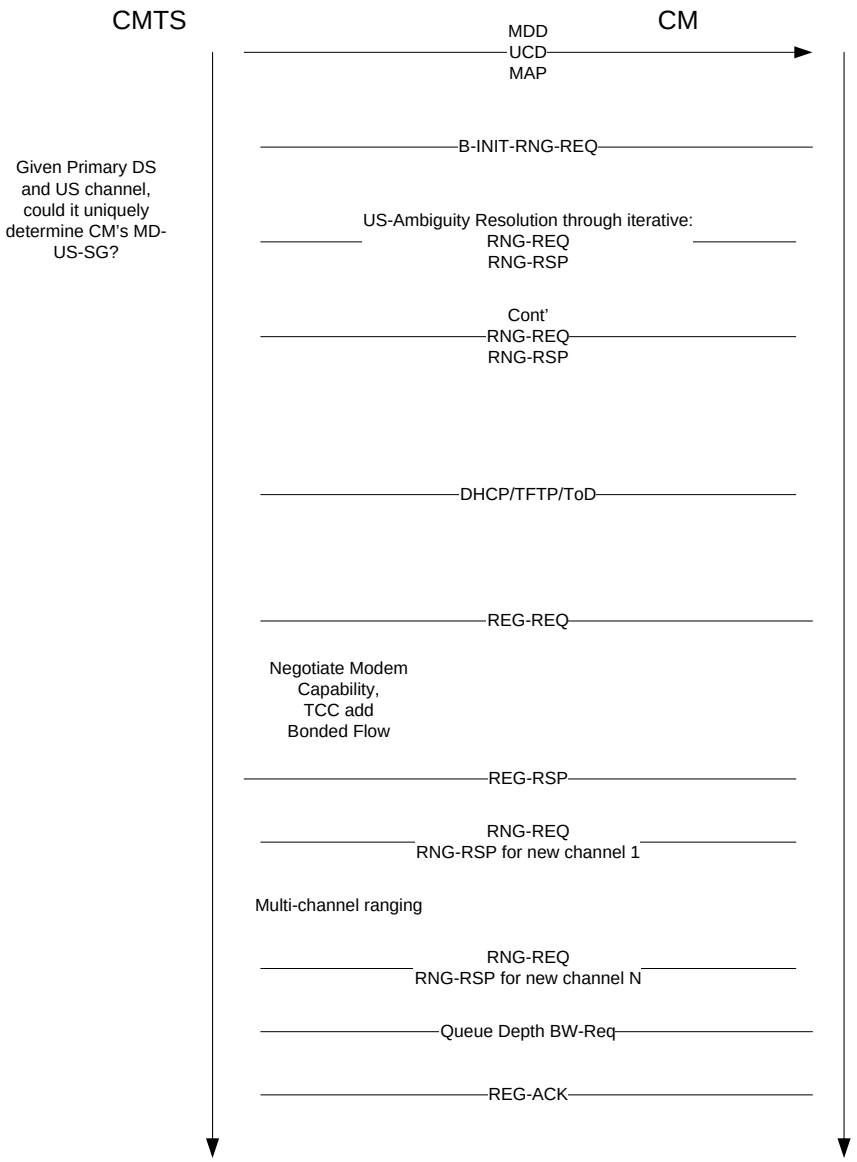
Registration sequence

- MDD
- B-INIT-RNG-REQ
- US-Ambiguity Resolution
- RNG-REQ/RNG-RSP
- DHCP
- TFTP/ToD
- REG-REQ/REG-RSP/REG-ACK



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Best Practices

Best practices to avoid possible voice issues

- Use nRTPS flow for signaling
- Monitor DS and US utilization
- Monitor RP and LC CPU utilization
- Proper capacity planning
- Wise use of SNMP polling for CMs and CMTS
- Use Service Flow Admission Control SFAC wisely
- Periodic health checkup for HFC plant

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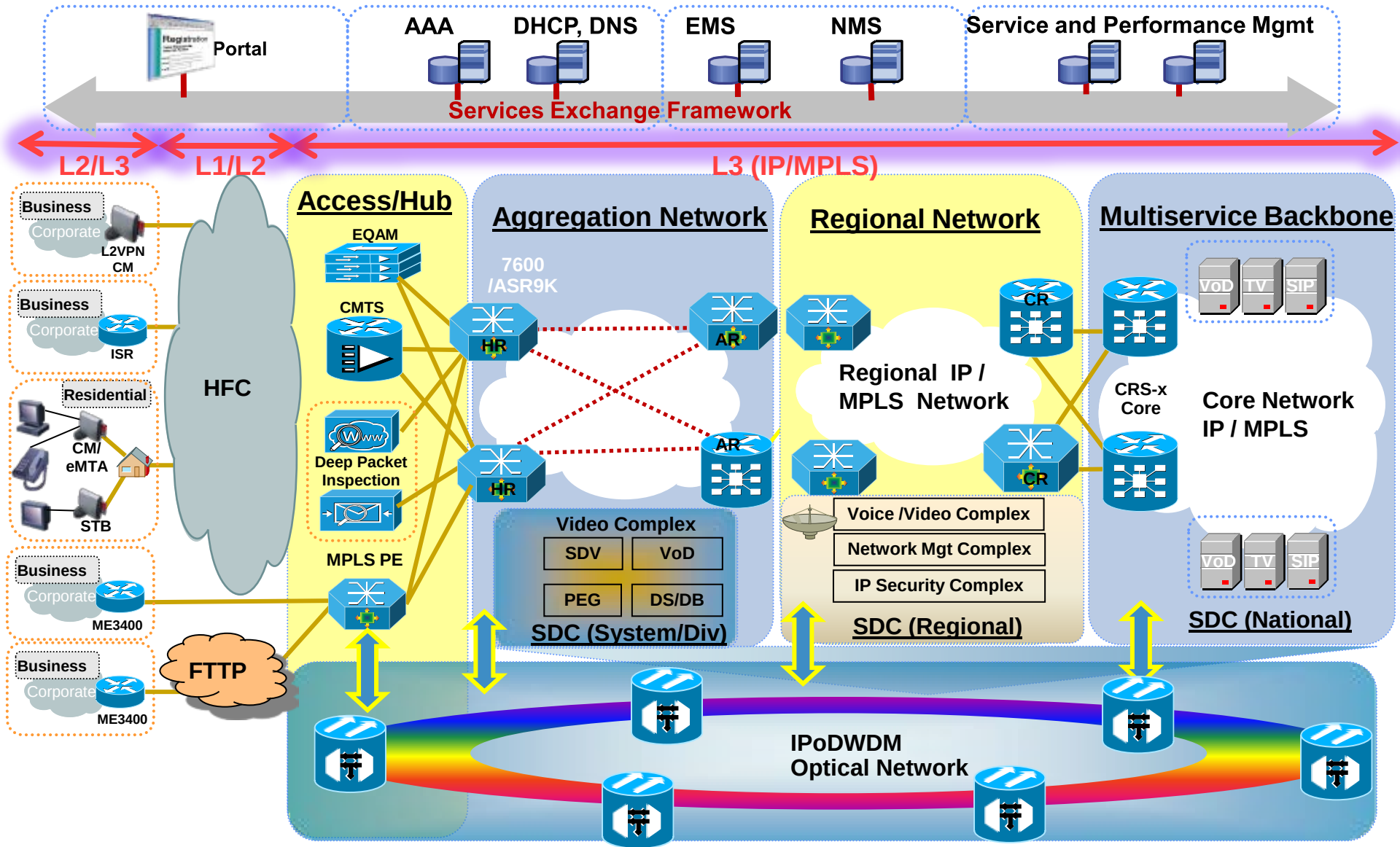
Cable Multi Service Networks



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